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Engagement in Cognitive Leisure Activities and Its Impact on the Quality of Life of Community-Dwelling Elderly Individuals

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Abstract

This study examined the relationship between cognitive leisure activities and quality of life among 126 community-dwelling elderly aged 60 and above. Using a quantitative cross-sectional design, the study employed the Cognitive and Leisure Activity Scale (CLAS) and the WHOQOL-OLD to explore levels of engagement and their relationship with well-being. Results revealed a significant positive correlation between active participation in cognitive leisure activities and improved quality of life. Despite a small sample size and self-report bias, the findings highlight the importance of promoting cognitive leisure activities through occupational therapy and community programs to enhance the well-being and life satisfaction of elderly.

Keywords: cognitive leisure, community-dwelling, elderly, quality of life

1.0 Introduction

Leisure refers to intrinsically motivated, voluntary activity performed in free time (American Occupational Therapy Association, 2014). There are special meanings that come with leisure that one might not be able to find in other occupations. Leisure is a feeling of independence (Craik & Pieris, 2006), a way to unwind physically and mentally from responsibilities and schedules (Roelofs, 1999), a way to explore one's personality and express oneself (Nadasen, 2008), and a way to interact with others (Kelly et al, 2017). Cognitive activities are mental tasks that demand concentration, attention, and focus, which are formed and developed during the educational process. Cognitive activity has traditionally been viewed as a subsection of mental activity (Korobova et al., 2018). In relation to cognitive and leisure, the term cognitive leisure is used to describe activities that involve a mental reaction from the participant, such as reading (Stern & Munn, 2010).

2.0 Literature Review

Engaging in cognitively demanding leisure activities during middle or later life can reduce the risk of Alzheimer's disease and other dementias (Stern & Munn, 2010). Lack of cognitive activity increases the risk of cognitive decline. Studies show that cognitive activities in free time enhance problem-solving, creativity, work ethic, and cognitive functioning. Older adults can improve psychological well-being, cognitive health, physical health, and quality of life through leisure activities, which also offer opportunities for social interaction and reduced depression (Dan, 2020 & Dergance et al., 2003).

Cognitive disability, depression, and psychiatric or medical conditions can negatively impact elderly well-being (Saracli et al., 2015). Quality of life (QOL) is an individual's perception shaped by aspirations, standards, and cultural values. QOL can relate to financial stability, job satisfaction, health, material circumstances, leisure, social life, financial security, and safety (Addington & Kalra, 2001). Treating cognitive impairments and depression during medical assessments can improve QOL for older adults (Saracli et al., 2015).

An article indicated people with dementia who resided in community-dwelling had better QOL than those in nursing homes with observing changes in cognitive and physical functions, social contacts, sleep patterns, exposure to light, and medication (Olsen et al., 12). Since cognitive leisure activity was not explored, thus, this study found gap that there could be relationship

between cognitive leisure and QOL among community-dwelling elderly. Community-dwelling refers to the older persons who reside outside of nursing facilities and living independently in community settings with their caregivers (Chi et al., 2019). This population are possibly engage in everyday life activities, social gatherings, and other parts of daily life depending on their interests, capabilities, and state of health or maybe wider range of pursuits.

3.0 Materials and Method

3.1 Study design and participants

A cross-sectional design was employed to examine the link between cognitive leisure activities and the QOL of elderly people living in communities, where respondents were enrolled through a purposive sampling method. They were 126 community-dwelling elderly aged 60 and above from nine districts in Selangor were approached through a social media platform. Those who fulfilled the inclusion criteria, such as being 60 years and above and living in a community-dwelling setting, were enrolled in this study. Those who are bedridden elderly, diagnosed with dementia, and live in institutions were excluded from the study.

3.2 Instrument of demographic characteristics

The demographic data consisted of questions regarding respondents' age, gender, district of residence, race, marital status, living arrangement, and health status. This information was used in determining the outcome and the relationship between demographic data and participation in cognitive leisure activities.

3.3 Instrument of the Cognitive and Leisure Activity Scale (CLAS)

The Cognitive and Leisure Activity Scale (CLAS), a quick assessment to calculate the dosage of cognitive activity engagement in older persons with and without cognitive impairment. It consists of sixteen items, each requiring a single best response based on six answer possibilities that best suit them. The items include passive activities, games, social activities, the arts, and exercise, with examples provided. Respondents were asked to reflect on the cognitive leisure activities they engaged in the previous year, as engagement in these activities may change over time. Frequency of activity was scored on 0-5 scale, collected as never (score 0), several times per year (score 1), several times per month (score 2), once per week (score 3), several times per week (score 4), and daily (score 5). The total involvement was then added to obtain the CLAS score, which ranges from 0 to 80 and indicates the "dose" of leisure and cognitive activities. The properties of this tool were outstanding, with a Cronbach's alpha of 0.731 and a 95% confidence interval of 0.67-0.78 (Galvin et al., 2021).

3.4 Instrument of the World Health Organisation Quality of Life Old Version (WHOQOL-OLD)

WHOQOL-OLD is designed for individuals aged 60 years or older (Fang et al., 2012), comprising modules that assess sensory functions, autonomy, past, present, and future actions, social engagement, death and dying, intimacy, and intimacy-related emotions (Fang et al., 2012). The tool consisted of 33 items, administered in a 15-minute self-administered format and scored using a 5-point Likert scale. Some items analyzed by reverse scoring had a total score range of 4 to 20. The psychometric properties are believed to be a strong and trusted instrument; Cronbach's alpha is within the range of $\alpha = 0.72$ to $\alpha = 0.88$, and the consistency coefficient is $\alpha = 0.89$.

3.5 Data collection procedures

Ethical approval granted from the Research Ethics Committee of the Universiti Teknologi MARA (UiTM) (FERC/FSK/MR/2023/00343). Prior to answering the questionnaires, respondents were briefed about the study, and then they provided consent after approving their participation in this study. It took about 10 to 15 minutes to answer the questionnaire. The results from the collected questionnaires via online were keyed in the Statistical Package for the Social Sciences (SPSS) 27.0 for recording and analysis purposes.

3.6 Data analysis

Data were analyzed using descriptive statistics (frequency, percentages, mean, and standard deviation) to explain the demographic background of participants, the findings of cognitive leisure activities, and the level of QOL perceived by the elderly. While the statistical analysis employed the Mann-Whitney U Test and Kruskal-Wallis test to examine the differences in cognitive leisure participation in relation to demographic factors (gender, marital status, and health status), and Spearman's Rank Correlation examined the relationship between cognitive leisure participation and QOL in community-dwelling elderly.

4.0 Results

4.1 Demographic characteristics of the community-dwelling elderly

Table 1 indicates that the elderly's mean age (SD) is 63.02 (7.12) with an age range of 60-80 years old ($n = 126$). The majority of them are aged 60-70 years old ($n=107$, 84.90%), with more than half of the elderly being males ($n=78$, 61.90%), married ($n=108$, 85.70%), living with family ($n=62$, 9.20%), and Malay ($n=98$, 77.80%). The majority of respondents reside in Hulu Langat, $n=60$

(47.60%), and many of them reported having medical conditions such as heart disease, hypertension, diabetes, high cholesterol, and kidney failure (n=58, 46%).

Table 1. Demographic Characteristics of Respondents (N=126)

Variables	n(%)	mean(SD)
Age		
60-70 years old	107(84.90)	63.02(7.19)
71-80 years old	19(15.10)	
Gender		
Female	78 (61.90)	
Male	48(38.10)	
Race		
Malay	98 (77.80)	
Chinese	18(14.30)	
Indian	10 (7.90)	
Health status		
No health issue	44(34.90)	
Orthopedic	24(19.00)	
Medical	58(46.00)	
Marital status		
Single	6(4.80)	
Married	108(85.70)	
Divorced	2(1.60)	
Widowed	10(7.90)	
Living arrangement		
Living with family	62(49.20)	
Living with spouse	54(42.90)	
Living alone	10(7.90)	
Residential area		
Petaling	20(15.90)	
Sabak Bernam	2(1.60)	
Kuala Selangor	14(11.10)	
Kuala Langat	4(3.20)	
Hulu Langat	60(47.60)	
Klang	6(4.80)	
Gombak	14(11.10)	
Hulu Selangor	2(1.60)	
Shah Alam	4(3.20)	

4.2 Participation in the cognitive leisure activity among community-dwelling elderly

Table 2 shows that respondents have low participation in cognitive leisure activities, with a score of 18 and below (n=70, 55.6%), with a mean score of 18.56 and a standard deviation of 7.86.

Table 2. Level of participation in the cognitive leisure activity among community-dwelling elderly

Level of cognitive leisure activity	N (%)	Mean (SD)
Total score CLAS		18.56 (7.86)
0-18 (Low participation)	70 (55.60)	
19-80 (High participation)	56 (44.40)	

In terms of type of cognitive leisure participated by the respondents, surprisingly, more than half percentage of elderly in the community dwelling reported they never attend a club or group activity outside house (n=84, 66.7%), attend to theater or concert or symphon (n=110 (87.30%), going to museum or exhibition (n=96, 76.2%), attend to conference or lecture or course (n=112, 88.9%) and write letter or poem or journal or diary as part of their leisure participation (n=106, 84.10%). Most importantly, there are daily favourite cognitive leisure activities that respondents most enjoy, such as watching TV or listening to music (n=66, 52.4%) and reading a newspaper/ book/ magazine (n=40, 31.7%), which they do every day, as proposed in Table 3.

Table 3. Descriptive analysis of the participation in the cognitive leisure activities among community-dwelling elderly

Question	Never (0) N (%)	Several times per year (1) N (%)	Several times per month (2) N (%)	Once a week (3) N (%)	Several times per week (4) N (%)	Daily (5) N (%)
Chess/ Checkers/ Backgammon	60 (47.60)	52 (41.30)	10 (7.90)	4 (3.20)	0 (0.00)	0 (0.00)
Crossword puzzles/ Jigsaw puzzles/ Sudoku	74 (58.70)	44 (34.90)	4 (3.20)	4 (3.20)	0 (0.00)	0 (0.00)

Playing cards/ Board games	56 (44.40)	54 (42.90)	10 (7.90)	4 (3.20)	2 (1.60)	0 (0.00)
Socializing with friends	8 (6.30)	30 (23.80)	44 (34.90)	16 (12.70)	12 (9.50)	16 (12.70)
Attending a club/ group activity outside the home	84 (66.70)	30 (23.80)	6 (4.80)	4 (3.20)	2 (1.60)	0 (0.00)
Volunteering	72 (57.10)	42 (33.30)	6 (4.80)	6 (4.80)	0 (0.00)	0 (0.00)
Painting/ drawing/ other arts/ crafts	70 (55.60)	42 (33.30)	4 (3.20)	8 (6.30)	2 (1.60)	0 (0.00)
Singing/ playing instrument	62 (49.20)	42 (33.30)	6 (4.80)	8 (6.30)	4 (3.20)	4 (3.20)
Watching TV/ listening to music	0 (0.00)	6 (4.80)	2 (1.60)	2 (1.60)	50 (39.70)	66 (52.40)
Reading a newspaper/ book/ magazine	4 (3.20)	30 (23.80)	6 (4.80)	12 (9.50)	34 (27.00)	40 (31.70)
Attending the theater/ concert/ symphony	110 (87.30)	8 (6.30)	6 (4.80)	2 (1.60)	0 (0.00)	0 (0.00)
Going to museum or exhibition	96 (76.20)	20 (15.90)	8 (6.30)	2 (1.60)	0 (0.00)	0 (0.00)
Attending a conference/ lecture/ course	112 (88.90)	8 (6.30)	2 (1.60)	2 (1.60)	2 (1.60)	0 (0.00)
Attending a religious service	60 (47.60)	26 (20.60)	6 (4.80)	10 (7.90)	18 (14.30)	6 (4.80)
Write a letter/ poem/ journal/ diary entry	106 (84.10)	8 (6.30)	4 (3.20)	6 (4.80)	0 (0.00)	2 (1.60)
Exercise	30 (23.80)	26 (20.60)	18 (14.30)	22 (17.50)	28 (22.20)	2 (1.60)

4.3 Quality of life of the community-dwelling elderly

Table 4 shows that community-dwelling elderly reported a high level of QOL, scoring 74 and above (n = 76, 60.3%), with a mean score of 73.95 and a standard deviation of 9.96.

Table 4. Descriptive Analysis of Respondents' Quality of Life

Level of quality of life	N (%)	Mean (SD)
Total score WHOQOL-OLD		73.9 (9.96)
24-73 (Low quality of life)	50 (39.70)	
74-120 (High quality of life)	76 (60.30)	

4.4 Differences in demographic background towards cognitive leisure activity

Based on Table 5, a Mann-Whitney test was conducted to assess the impact of gender on cognitive leisure activities. Findings indicated no significant difference in cognitive leisure activity between males (Md=18, n=78) and females (Md=17, n=48), U = 1688, z = -0.927, p = 0.354.

While the Kruskal-Wallis Test was performed to evaluate the influence of marital status on cognitive leisure activity, it proved a statistically significant result with $X^2(3) = 5.370$, p = 0.045. Because this significant value is met, the finding indicates that the median divorced individual is likely to engage in more cognitive leisure activities than the married, widowed, and single.

Other than that, the Kruskal-Wallis test also revealed a statistically significant difference in health status towards cognitive leisure activity, with $X^2(2) = 18.350$, p = 0.001. Because this significant value is met, the finding suggests that the median health status is likely to be better in cognitive leisure activities than in medical and orthopedic conditions.

Table 5. Difference in Demographic Background with Cognitive Leisure Activity

Variable	n	Median (IQR)	Cognitive Leisure Activity Z statistic	P value
Gender			-0.927	0.354
Male	78	18(8)		
Female	48	17(9)		
Marital status	n	Median (IQR)	X^2 (df)	P-value
Married	108	18(6)	5.370(3)	0.045*
Divorced	2	20(0)		
Widowed	10	10(7)		
Single	6	15(16)		
Health status			18.350(2)	0.001*
No health issue	44	21(6)		

Orthopedic	24	16(6)
Medical	58	16(8)

*Significant value at $p < 0.05$

4.5 Association of cognitive leisure activity and the quality of life of the elderly in community-dwelling

The correlation between cognitive leisure activity and the quality of life of the elderly is shown in Table 6. Findings indicated a positive correlation between cognitive leisure activities and the quality of life of the elderly. The relationship between cognitive leisure activity (as measured by the CLAS) and quality of life (as measured by the WHOQOL-OLD) was investigated using Spearman's rank correlation coefficient. There was a weak positive correlation between the two variables ($r = 0.259$, $p = 0.003$, $n = 126$), indicating that higher participation in cognitive leisure activities is associated with a higher quality of life among community-dwelling elderly.

Table 6. Association between cognitive leisure activity and quality of life of the elderly

Variable	Quality of Life	
	Rho (r)	p-value
Cognitive Leisure Activity	0.259	0.003*

*Correlation is significant at the 0.01 level (2 tailed).

5.0 Discussion

Results from the study show that the most preferred cognitive leisure activity among community-dwelling elderly was enjoying socializing with friends, watching TV, listening to music, and reading a newspaper/ book/ magazine. A study by Hamid et al. (2019) found that religious activities were among the most frequently reported leisure activities among elderly Malaysians. Many elderly Malaysians participate in religious activities, including attending prayers, religious classes, and community religious events. This is not only a source of spiritual fulfilment but also a means to maintain social connections and mental well-being.

While Ibrahim et al. (2013) found that elderly individuals in Malaysia are interested in socializing with family and friends, this is a key leisure activity for them. This includes family gatherings, visiting friends, and attending community events. These social interactions are crucial for providing emotional support and reducing feelings of loneliness. This previous study supports the result of this study.

In addition, based on previous studies by Lim and Kua (2011), participation in such clubs is a significant leisure activity among the elderly. Many elderly individuals participate in senior citizen clubs or associations, which offer a range of organized activities, workshops, and outings. These clubs promote active aging and provide structured social opportunities.

In terms of participation in cognitive leisure activity, community-dwelling elderly in Selangor have low participation compared to the elderly in community-dwelling in Japan (Yokoyama & Miwa, 2020), with the mean score of the cognitive leisure activity being 9.9-11.0, indicating that most of the elderly have high participation in cognitive leisure activity. This highlighted that the higher engagement in cognitive leisure activities among the elderly in Japan was due to several cultural, social, and structural factors. These differences reflect the unique historical, educational, and societal contexts of each country. One of them is cultural emphasis on lifelong learning. Yokoyama & Miwa (2020) highlight that this cultural emphasis on education and mental stimulation contributed to the active engagement of the elderly. There is a strong cultural emphasis on lifelong learning and intellectual engagement. The concept of "shūgaku" (lifelong learning) is deeply ingrained in Japanese society, promoting continuous education and self-improvement at all stages of life. This cultural value fosters a high level of engagement in cognitive activities, such as reading, puzzles, and acquiring new skills (Yokoyama & Miwa, 2020).

In contrast, while Malaysia also values education, the emphasis on lifelong learning and intellectual pursuits among the elderly may not be as pronounced. In many elderly communities, the focus is often more on social and physical activities, influenced by the diverse cultural backgrounds and lifestyles in Malaysia (Ibrahim et al., 2013).

In terms of gender differences, male and female participants did not significantly differ in their cognitive leisure activities, which contrasts with the findings of the previous study. Women are generally more involved in social and group activities, such as community events, book clubs, and cultural activities, which provide cognitive stimulation and social interaction (Verghese et al., 2003). On the other hand, men are more likely to engage in solitary cognitive activities, such as reading, playing strategic games like chess, and using computers, which also contribute to cognitive health but may offer different social benefits (Addams et al., 2011). While Rahim et al. (2023) agree that women tend to participate more in social and cognitive activities, men are more engaged in physical activities.

Hormonal influences, such as higher levels of testosterone in men and estrogen in women, play a role in behavioral tendencies. Testosterone is associated with physical aggression and competitiveness, which may lead men to prefer physical activities (Vongas & Al-Hajj, 2017). In contrast, estrogen is associated with nurturing and social bonding behaviors, which can lead women to engage more in social and cognitive activities (McCarthy & Garavan, 2008).

Besides, Studies have shown differences in brain structure between men and women. For instance, women generally have a larger corpus callosum, which enhances communication between brain hemispheres, potentially supporting better social and cognitive skills than men (Ingahalikar et al., 2014).

Other than that, the data in this study indicated a significant difference in the marital status of the elderly and their participation in cognitive leisure activities among the elderly in community dwellings. Contrary to some expectations, findings of the previous studies have shown that marital status does not significantly influence cognitive leisure activity engagement among the elderly. For example, although social support is crucial for cognitive health, the source of that support (spousal or otherwise) did not significantly alter participation in cognitive activities (Lee et al., 2018). This suggests that being married or single, widowed, or divorced does not necessarily affect an individual's likelihood of engaging in cognitive activities.

While marital status itself is not a significant factor, the broader social network and social interactions might be more relevant. Research indicated that having a diverse social network, which includes friends, family members, and community contacts, is more predictive of engagement in cognitive activities than marital status alone (Lee et al., 2018). Elderly individuals often participate in cognitive activities through community centers, clubs, or informal social gatherings, which can be independent of their marital status.

Divorced elderly individuals often experience increased autonomy and independence, which allows them to pursue personal interests without the constraints of marital responsibilities. This autonomy can lead to higher engagement in cognitive leisure activities, such as reading, puzzles, and learning new skills (Kim et al., 2020). Freed from shared household responsibilities and caregiving duties allowed single elderly individuals to have more opportunities to participate in mentally stimulating activities (Han et al., 2020).

This study also revealed that the elderly's health status had an influence on their cognitive leisure activity. Those in better physical health were more likely to engage in cognitive activities, which in turn improved their cognitive performance (Xian et al., 2024). Medical conditions often result in physical limitations that hinder the elderly's ability to engage in cognitive leisure activities. For instance, chronic pain, mobility limitations, and fatigue associated with conditions like arthritis or heart disease may limit individuals' capacity to participate in mentally stimulating activities (Stern & Munn, 2010). Additionally, cognitive impairments such as mild cognitive impairment (MCI) or dementia can affect individuals' cognitive function and their ability to engage in cognitively demanding leisure pursuits (Scherder et al., 2005). Furthermore, psychological distress resulting from medical conditions, such as depression or anxiety, can further reduce motivation and interest in engaging in leisure activities (Ng et al., 2009).

Another finding in this study revealed a relationship between cognitive leisure activity and the quality of life of community-dwelling elderly individuals, where increased participation in cognitive leisure activities contributes to a higher level of quality of life. A previous study demonstrated that elderly individuals who regularly engaged in cognitive activities had a lower risk of developing dementia, which directly supports the benefits of maintaining better cognitive health and overall quality of life (Hao & Kim, 2024). Engagement in diverse cognitive leisure activities fosters social connections, provides a sense of purpose and enjoyment, and is associated with higher levels of life satisfaction and lower levels of depressive symptoms, thereby enhancing overall quality of life (Han et al., 2020). For instance, chess-playing promotes mental engagement and social interaction with partners, which contribute to significant positive effects on the cognitive performance of the elderly, thereby improving various aspects of cognitive function and overall quality of life (Vale et al., 2018). Additionally, the structured and interactive nature of the chess-playing sessions provided a mentally stimulating and enjoyable activity that promotes social connections, offers participants a sense of purpose and achievement, and contributes to enhanced well-being (Ciberia et al., 2021).

6.0 Conclusion

This study examined the relationship between cognitive leisure activities and the quality of life among community-dwelling elderly in Selangor, using a cross-sectional, quantitative methodology with 126 respondents. Key findings revealed that 44.4% of participants were highly engaged in cognitive leisure activities. Significant demographic factors affecting participation included marital status and health status. Despite limitations such as a small sample size and reliance on self-report questionnaires, the study highlighted the importance of cognitive leisure activities in enhancing the quality of life among the elderly. Future research should consider larger sample sizes and additional demographic factors to validate and expand upon these findings. This study emphasized the need of engagement in cognitive leisure activities, which cognitive stimulation activities embedded into leisure activities possibly provide enjoyment and influence overall quality of life among community-dwelling elderly. Additionally, addressing the need for targeted occupational therapy interventions and community support programs to facilitate such engagement among community-dwelling elderly individuals.

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Paper Contribution to Related Field of Study

This study highlighted the importance of keeping the elderly active throughout their life which occupational therapists could assess and help to install leisure activities for them. It also an eye opener for community to understand the essential of maintaining quality of life in the elderly with targeting those with higher risk or possibly have reduce cognitive and QOL due to their underlying factors.

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Death Anxiety and Self-Esteem Among Youth in Malaysia

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Abstract

This study explores the relationship between death anxiety and self-esteem among Malaysian youth aged 18–30. An online cross-sectional survey of 394 participants employed the Collett-Lester Fear of Death Scale (Version 3) and the Rosenberg Self-Esteem Scale. Results indicated moderate to high death anxiety and lower self-esteem levels. Female participants reported significantly higher death anxiety than males ($p = 0.003$). No significant correlations were found between age and death anxiety ($r = 0.032$, $p = 0.527$) or between death anxiety and self-esteem ($r = -0.085$, $p = 0.092$). Findings highlight death anxiety as a growing psychological concern among Malaysian youth.

Keywords: Death Anxiety; Youth; Self-Esteem; CL-FODS

1.0 Introduction

Death embodies the finality of life, and death anxiety reflects our innate desire to evade it (Moore & Williamson, 2003). Death is the only certainty in human existence, it remains paradoxically the leading source of anxiety (Nyatanga & De Vocht, 2006). This anxiety may stem from the inescapable yet unpredictable nature of death, which can occur indiscriminately. Additionally, the limitations of human knowledge and science in fully understanding or controlling death contribute to this anxiety. The lingering question of what occurs after death further deepens its mystery. It is a natural inclination to shy away from contemplating death, as many prefer to concentrate on life's offerings. Since death is inevitable, it is perfectly normal to feel nervous about it, but it becomes an issue when that anxiety interferes with or paralyzes day-to-day functioning (Furer & Walker, 2008). Individuals with a heightened fear of death often experience distressing or intrusive thoughts that disrupt their daily lives and relationships. They tend to avoid situations related to death or dying and become increasingly anxious when the topic arises.

People tend to personalise death-related situations, which makes them think about how mortality can affect their own life and causes this increased worry (Adeeb et al., 2017). Since death is the ultimate finality of life, it is only normal for people to be afraid of it and to want to escape it; this is known as death anxiety. Although death is an unavoidable fact, this fear is made even more intense by its inherent unpredictable nature and the fact that we have no control over it. A number of variables, including age, gender, education, culture, and psychological condition, might contribute to severe death fear, which can show up as symptoms including panic, dread, and compulsive health monitoring (Hoelterhoff & Chung, 2013; Adeeb et al., 2017; Khormaei, Dehbid, & Hassanzehi, 2017). Furthermore, factors including isolation, pessimism, and a lack of social support might make death anxiety becoming worse (Adeeb et al., 2017; Chow, 2017; Barnett, Anderson & Marsden, 2018). Psychological illnesses such as obsessive-compulsive disorders, depression, and panic attacks can result from this death anxiety if left untreated (Furer & Walker, 2008). Anxiety over death is a typical human tendency that can exacerbate existing misery. In an effort to manage these anxieties, people frequently work to uphold a good view of themselves and a feeling of purpose in life, which gives their lives value and eventually lessens their anxiety of dying (Chung, Cha & Cho, 2015). Self-esteem is a vital component in protecting people from the fear of death that comes with it. A high sense of self-worth is a powerful protective factor against death anxiety, offering stability and reducing mortality-related anxieties. In contrast, a higher likelihood of depression and suicidal ideation is associated with low self-esteem (Chung, Cha & Cho, 2015). Findings from research on death anxiety are mixed, with some showing higher anxiety levels in older persons and others reporting a higher incidence in younger people (Missler et al., 2012; Rajkumar & Suresh Singh, 2013). The Department of Statistics Malaysia (DOSM) estimates that there are six million Malaysians are between the ages of 18 and 30.

This group shows a higher chance of experiencing death anxiety, especially when faced with life-threatening circumstances or the passing of peers (Özdemir, Kahraman & Ertufan, 2021).

Young people frequently have many goals to be achieved, which might increase their concern about dying too soon and preventing these goals from being fulfilled (Özdemir, Kahraman & Ertufan, 2021). The stage of development greatly influences how people regard death, but the self-centred mindset that permeates young people can result in a sense of invincibility and the conviction that they are impervious to death. Strong emotional reactions to death such as denial, rage, guilt, and extreme grief, may be brought on by this delusion (Wass, 2004). Adults, on the other hand, often view death as a personal insult and a cause of disappointment, which might impair their ability to be joyful and take on responsibilities (Savi Çakar, 2020). The study on death anxiety indicates that young people are less likely to deal with death and, thus, have lower levels of death anxiety. However, there is a contradiction in that other studies imply that young people may have higher levels of worry (Macleod, 2016; Eric Reyes, 2017). Young individuals may experience higher levels of death anxiety as a result of the relative rarity of death in their 20s combined with existential unpredictability about mortality (Savi Çakar, 2020). However, there is empirical evidence from several research that suggests older persons may have higher levels of death fear (Missler, 2012; Dadfar et al., 2021). This discrepancy in results highlights the complex relationship between death dread and age, as well as the several psychological processes involved. There is still limited understanding of how death anxiety affects young people, as research has mainly centred on the elderly, creating a significant gap in knowledge regarding younger individuals.

2.0 Methodology

2.1 Study design

A total of 394 youth (n=394) were recruited from various locations across Malaysia for this cross-sectional study, surpassing the initial target of 377 participants. Convenience sampling was utilized following ethical approval from the Ethics Committee of Universiti Teknologi MARA (UiTM) (FERC/FSK/MR.2023/00245). Participation was restricted to those respondents who met the inclusion criteria and provided informed consent prior to completing the survey. Based on the sample size calculation, 377 participants were required for this study. However, 394 participants (n=394) responded, all of whom completed the full questionnaire and met the specified inclusion and exclusion criteria: (a) aged between 18 and 30 years and (b) able to read and understand English. Individuals with severe mental health conditions, chronic illnesses, or terminal illnesses were excluded from participation.

2.2 Data collection procedure

An English-language questionnaire was distributed online through email, Facebook, WhatsApp, TikTok, and other channels. It was divided into three sections: the Rosenberg Self-Esteem Scale (RSES), the Revised Collett-Lester Fear of Death Scale Version 3 (CL-FODS), and demographic data. Age, gender, ethnicity, religion, educational background, employment status, and marital status were all collected in the demographic section. The CL-FODS evaluated respondents' discomfort or anxiety levels when contemplating death and dying in order to measure death anxiety. The scale assessed four different types of fears: dying of oneself, dying of others, dying of oneself, and dying of others. There were 28 questions in all, with seven things in each fear category. One on the 5-point Likert-type scale meant "not upset/disturbed/anxious," and five meant "very upset/disturbed/anxious." Higher scores indicated more anxiety over thoughts of death. With Cronbach's alphas of 0.91, 0.92, 0.88, and 0.92 for each of the four subscales, the scale showed excellent reliability. All of the item-total correlations were positive and above 0.47, which was an improvement over the previous version (Lester & Abdel-Khalek, 2003). The 10-item RSES self-report measure evaluated both positive and negative self-perceptions in order to determine global self-worth. On a 4-point Likert scale that goes from "strongly agree" to "strongly disagree," respondents indicated how much they agreed. Stronger scores indicated stronger self-esteem. Items 2, 5, 6, 8, and 9 were reverse-scored. With test-retest reliability correlations of 0.85 and 0.88 and Cronbach's alpha for various samples are in the range of 0.77 to 0.88 (Rosenberg, 1965). Significant connections with other measures of self-esteem and its anticipated associations with anxiety and depression demonstrated its validity. (Rosenberg, 1965).

2.3 Data analysis

Version 28 of the Statistical Package for the Social Sciences (SPSS) was used to analyse the information gathered from respondents' self-report questionnaires. To summarise the respondents' demographic traits, degrees of death dread, and self-esteem, a descriptive analysis was conducted. Using the Mann-Whitney U-test, gender differences in death anxiety were assessed. Using the Spearman Correlation test, the association between self-esteem and death anxiety was also examined.

3.0 Findings

The study's respondents ranged in age from 18 to 30 years old, with 74.6% being female (n=294) and 25.4% being male (n=100).

Their mean age was 22.40 years (SD = 2.627). The demographic information, including age, gender, race, religion, marital status, educational attainment, and job status, is summarised in Table 1. The vast majority of respondents lived in Selangor (36.5%, n=144) and identified as Malay (93.7%, n=369). Islam was the most common religion (95.4%, n = 376), followed by Christianity (4.6%, n = 18). Of the 375 respondents, 95.2% were unmarried, while 19 respondents, or 4.8%, were married. Furthermore, the majority of respondents (82.7%, n=326) were students, and 55.3% of them had a degree (n=218).

Table 1: Demographic Data

Characteristics	Frequency (n)	Percentage (%)
Gender		
Female	294	74.6
Male	100	25.4
State of Residence		
Selangor	144	36.5
Johor	31	7.9
Kelantan	30	7.6
Pahang	25	6.3
Perak	24	6.1
Federal Territory of Kuala Lumpur	24	6.1
Terengganu	21	5.3
Kedah	20	5.1
Sabah	20	5.1
Sarawak	17	4.3
N. Sembilan	14	3.6
Malacca	13	3.3
P. Pinang	8	2.0
Putrajaya	2	0.5
Perlis	1	0.3
Race		
Malay	369	93.7
Bumiputera Sabah	7	1.9
Dusun	4	1.0
Kadazan	3	0.8
Iban	3	0.8
Bumiputera Sarawak	2	0.5
Melanau	2	0.5
Dayak	1	0.2
Bajau	1	0.2
Rungus	1	0.2
Murut	1	0.2
Religion		
Islam	376	95.4
Christianity	18	4.6
Marital Status		
Single	375	95.2
Married	19	4.8
Education Level		
Degree	218	55.3
Diploma	120	30.5
SPM	30	7.6
Foundation	13	3.3
Master	13	3.3
Employment Status		
Students	326	82.7
Employed	51	12.9
Unemployed	17	4.3
	Mean	SD
Age (Year)	22.40	2.63

As detailed in Table 2, participants reported moderate to high levels of death anxiety, with a mean score of 3.6 out of 5 (SD = 0.71). A total of 52.8% (n = 208) of respondents exhibited moderate to high levels of fear related to death. Table 3 presents the self-esteem scores of the participants, revealing a mean score of 14.41 (SD = 5.37), indicative of generally low self-esteem within the sample.

Table 2: Level of death anxiety

Variables	Frequency (n)	Percentage (%)	Mean	SD
Death Anxiety				
Low fear of death	2	0.5		

Low to moderate fear of death	8	2.0		
Moderate fear of death	65	16.5		
Moderate to high fear of death	208	52.8		
High fear of death	111	28.2		
Death anxiety			3.6	0.71

Table 3: Level of self-esteem

Variables	Frequency (n)	Percentage (%)	Mean	SD
Self-Esteem				
High	204	51.8		
Low	190	48.2		
Self-esteem			14.41	5.37

Nevertheless, 51.8% (n = 204) of respondents demonstrated comparatively higher levels of self-esteem. Table 4 examines gender differences in death anxiety, with findings indicating that female respondents reported significantly higher levels of death anxiety than their male counterparts ($Z = 2.974$, $p = 0.003$). The association between age and death anxiety is explored in Table 5, where a weak positive correlation was observed ($r = 0.032$, $p = 0.527$); however, this association did not reach statistical significance.

Table 4: Differences between gender and level of death anxiety

Variable	Attitude		
	Median (IQR)	Z statistic	P value
Gender			
Female	3.77	2.974	.003
Male	3.39		

Table 5: Association between age and death anxiety

Variable	Age	
	Spearman rho (r)	p-value
Age		
Death anxiety	0.032	0.527

Lastly, Table 6 investigates the relationship between self-esteem and death anxiety, revealing a weak negative correlation ($r = -0.085$, $p = 0.092$), suggesting a potential inverse relationship, although the result was not statistically significant.

Table 6: Association between death anxiety and self-esteem

Variable	Death Anxiety	
	Spearman rho (r)	p-value
Self esteem	-0.085	0.092

4.0 Discussion

The findings of the study indicate that the majority of respondents reported moderate to high levels of death anxiety, with only a small minority exhibiting low to moderate levels. These results affirm the presence of death anxiety among Malaysian youth and align with previous research suggesting that younger individuals tend to experience heightened levels of death anxiety (Macleod et al.,2016; Eric Reyes et al.,2017). Youth's higher levels of death fear may be related to their developmental period, which is characterised by goals and ambitions that death might upset (Özdemir, Kahraman & Ertufan,2021). Additionally, young people's egocentric viewpoint causes them to concentrate intently on how death affects them personally, which deepens their observations on mortality (Robin & Omar,2014). The uncertainty and fear associated with mortality may be more intense for young people, who are often less exposed to it. Youth's tendency towards self-centredness affects how they see mortality, contributing to their assumption that they are immune to an early death. Experiencing a peer's death might elicit strong emotional responses, such as denial, annoyance, and deep grief (Wass,2004). Death anxiety is made worse by the inescapability and unpredictable nature of death as well as its resistance to science or human intervention. Due to this ambiguity, people frequently view death negatively, which makes them more afraid (Macleod et al.,2016; Eric Reyes et al.,2017).

A significant gender difference in death anxiety was also found by the study, with women often reporting higher levels of fear. They are in line with previous research (Savi Çakar,2020; Özdemir, Kahraman & Ertufan,2021). The increased death dread that

women experience is often explained by the fact that they are more likely to have unpleasant feelings when faced with death-related issues. Women tend to be more preoccupied with mortality than men and, unlike men, are more inclined to express feelings such as sadness, fear, and sorrow, while men often suppress these emotions (Arnett, 2013). Men and women approach death anxiety differently; women typically engage with it through emotional responses, whereas men adopt a more cognitive perspective (Lyke, 2013). The relationship between gender and death anxiety can differ based on age and the particular aspects of death anxiety under consideration, which may account for findings that some studies report men exhibiting higher death anxiety than women (Dadfar et al., 2021). This study identified a weak positive association between age and death anxiety, indicating that as individuals age, their anxiety surrounding death tends to increase. Given that the respondents in this study were relatively young, their concerns about death may escalate as they grow older. Youth is often a time when individuals begin to contemplate mortality, especially when confronted with the deaths of others. Such experiences can lead young people to reflect more personally on their own mortality, potentially heightening their death anxiety (Robin, & Omar, 2014).

Simultaneously, youth is a transitional phase characterized by hope and aspirations for the future (Özdemir, Kahraman & Ertufan, 2021). The dread of dying intensifies throughout this period as people grow increasingly aware that their mortality may prevent them from pursuing their goals and aspirations. The study's results are consistent with other studies showing that young individuals often have greater levels of death fear (Macleod et al., 2016; Eric Reyes et al., 2017). Death anxiety is particularly salient among older adults and individuals in midlife, largely due to increased awareness of mortality and exposure to age-related losses (Maxfield, John & Pyszczynski, 2014). As individuals progress through their lifespan, they often encounter significant life events such as retirement, declining physical health, and the death of peers or family members, all of which may heighten existential concerns (Maxfield, John & Pyszczynski, 2014). Furthermore, socio-cultural attitudes toward ageing and death, alongside personal beliefs regarding the afterlife and life's meaning, significantly shape the experience of death anxiety in this age group (Iverach, Menzies & Menzies, 2014). Recognizing the heightened vulnerability in these populations is essential for informing targeted mental health interventions. Interventions such as existential therapy, meaning-centred therapy, and grief-focused counselling have demonstrated the potential to reduce death-related distress and foster psychological well-being among older adults. Additionally, integrating public health initiatives that encourage open dialogue about death and promote adaptive coping strategies can contribute to reducing stigma and enhancing emotional resilience in ageing populations. According to the results, there is not enough data to conclude that self-esteem and death anxiety are significantly correlated.

On the other hand, a slight negative association was found, suggesting that lower levels of death dread are linked to greater levels of self-esteem. This result is consistent with other studies on the connection between self-esteem and death dread (Chung, Cha & Cho, 2015; Özdemir, Kahraman & Ertufan, 2021). One important psychological process that reduces existential dread associated with death and dying is self-esteem. According to their Terror Management Theory (TMT), self-worth serves as a buffer against death dread and the emotional fallout that follows. It acts as a buffer, protecting people from the knowledge of their fragility and the fear of dying (Greenberg, Pyszczynski & Solomon, 1986). People may be more prone to death-related worries when they have low self-esteem (Abeyta, Juhl & Routledge, 2014). In the end, having a high sense of self-worth promotes a more positive outlook on mortality, which in turn serves to lessen death anxiety. Higher self-esteem is linked to lower levels of death anxiety and more adaptive attitudes towards death (Abeyta, Juhl & Routledge, 2014).

5.0 Conclusion & Recommendations

In conclusion, this study contributes to the understanding of youth mental health by examining the relationship between self-esteem and death anxiety among Malaysian youth. Youth in Malaysia experienced moderate to high death anxiety, with females reporting significantly higher levels than males, indicating a gender difference. Although no significant associations were found between death anxiety and either age or self-esteem, the observed patterns suggest potential links that warrant further study. Limitations include the cross-sectional design, sample homogeneity, and self-reported data, which may affect generalizability. Future research should explore mediating factors such as social support, cultural values, and coping strategies. Addressing death anxiety through interventions that enhance self-esteem and resilience may help improve the psychological well-being of Malaysian youth.

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Paper Contribution to Related Field of Study

This paper contributes to the field by exploring the relationship between death anxiety and self-esteem among Malaysian youth,

focusing on the influence of cultural and societal factors. It fills a gap in understanding how death anxiety affects self-esteem in a multicultural setting. The findings provide useful insights for developing mental health interventions and policies suited to the needs of Malaysian youth.

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Evolving Learning Through Community Engagement: A Three-Year Reflection on Dental Students' Experiences with Individuals with Special Needs

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Abstract

This study examines the evolving reflections of three cohorts of final-year dental students who participated in a community engagement program involving individuals with special needs (IWSN). A total of 240 students planned and conducted oral health activities in community institutions, followed by guided reflective writing. Thematic analysis revealed progressive learning across cohorts: Cohort 1 developed awareness and empathy, Cohort 2 enhanced communication and behavioural management skills, and Cohort 3 demonstrated leadership and advocacy. These findings illustrate how experiential learning transforms classroom-based knowledge into social responsibility, embodying UiTM's SULAM philosophy and the CSSR 2025 theme, "From Classrooms to Society".

Keywords: Dental Education; Community Engagement; Reflective Learning; Special Needs

1.0 Introduction

Delivering equitable oral healthcare to individuals with special needs (IWSN) is an essential competency for dental professionals. Yet, this population continues to face barriers in accessing care, and many dental graduates report low confidence in managing their needs. These challenges highlight the need for undergraduate dental programs to prepare future practitioners who are both competent and compassionate in serving diverse communities.

Universiti Teknologi MARA (UiTM) embraces the philosophy of "University for Society" through the Service Learning Malaysia University for Society (SULAM) initiative, which integrates academic excellence with social responsibility. Within this framework, community engagement is a structured pedagogical approach that connects theoretical knowledge with real-world application, fostering empathy, communication, and advocacy among students.

To address this educational priority, the Faculty of Dentistry at UiTM introduced a community engagement program with IWSN as part of its Special Care Dentistry curriculum. Final-year students design and implement oral health activities at community institutions, gaining authentic experience in communication, behavioural management, and teamwork.

Over time, the program has maintained a consistent structure consisting of preparatory workshops before the visits and reflective debriefing sessions after each event. Successive cohorts experienced enhancements in the quality of oral health demonstrations, the integration of innovative educational tools and interactive activities, and the introduction of peer evaluation and feedback as part of assessment. These refinements were implemented to strengthen students' engagement, creativity, and accountability, while further deepening the learning experience and professional development outcomes.

While previous studies have shown that community engagement enhances empathy and clinical skills, little is known about how learning outcomes evolve across multiple cohorts within the same program. This study therefore, explores the reflections of three consecutive student cohorts, aiming to identify how their learning focus and professional identity developed over time, and how experiential learning transforms classroom knowledge into social responsibility.

2.0 Literature Review

2.1 Preparing Dental Students for Inclusive Oral Healthcare

Delivering quality oral healthcare to individuals with special needs (IWSN) requires more than clinical skill as it demands empathy, adaptability, and understanding of the psychosocial factors that influence care. However, studies consistently report that undergraduate dental students feel underprepared and lack confidence in managing such patients (Ahmad, Razak & Borromeo, 2015; Naimie et al., 2020). Traditional didactic teaching, while necessary, may not adequately equip students with the interpersonal and behavioral management skills needed for inclusive care. As a result, educators are increasingly turning to experiential and community-based approaches to develop these competencies.

2.2 Experiential Learning as a Transformative Pedagogy

Experiential learning, conceptualised by Kolb (1984), posits that knowledge is constructed through a cyclical process involving concrete experience, reflective observation, abstract conceptualisation, and active experimentation. In dental education, this approach enables students to engage in real-world encounters that contextualise theoretical knowledge. Previous studies have shown that when dental students participate in community or outreach programs, they not only acquire practical skills but also demonstrate growth in empathy, communication, and professionalism (Angelopoulou & Kavvadia, 2018; Witton & Paisi, 2022). Such experiences promote deep learning where students evolve from merely performing clinical tasks to understanding the broader social and ethical dimensions of care. This transformation is particularly critical in special care dentistry, where sensitivity and compassion are central to effective practice.

2.3 Community Engagement and the SULAM Philosophy

Community engagement in higher education serves as a bridge between universities and society. The Malaysian Ministry of Higher Education's Service Learning Malaysia – University for Society (SULAM) initiative reinforces this by encouraging institutions to integrate academic content with civic engagement and community partnership.

In the context of dental education, community engagement provides opportunities for students to design and implement oral health promotion activities for underserved or marginalised populations, including individuals with disabilities. Such experiences promote a sense of civic responsibility, teamwork, and leadership, qualities that extend beyond clinical competence (Kuthy et al., 2010; Evans et al., 2021). By engaging directly with IWSN, students develop greater cultural and social awareness. They begin to see oral health not merely as a technical service but as a right that requires advocacy and accessibility. This process aligns with UiTM's institutional mission of producing graduates who are both competent professionals and compassionate contributors to society.

2.4 Reflection as a Catalyst for Professional Identity Formation

Reflection transforms experience into learning. According to Schön (1983) and Mezirow (2000), reflective practice encourages learners to critically examine their assumptions and emotions, leading to deeper self-awareness and professional identity formation. In health professions education, structured reflection helps students move from surface-level descriptions of events to more analytical and transformative thinking (Ng et al., 2021).

For dental students, reflecting on encounters with IWSN allows them to process emotional reactions, recognise biases, and articulate personal growth. Over time, repeated exposure and guided reflection foster a shift from empathy to advocacy, where students not only understand the challenges faced by patients with disabilities but also feel responsible for addressing inequities in access to care.

2.5 Longitudinal Perspectives in Educational Research

Most studies on experiential and community-based learning report findings from a single cohort or intervention. However, longitudinal and multi-cohort analyses can provide richer insights into how educational innovations evolve and mature. Tracking different cohorts allows educators to evaluate whether program refinements such as preparatory workshops, reflective templates, or debriefing sessions translate into deeper learning outcomes over time (Glassick, 2000).

In dental education, longitudinal reflection analysis remains limited, especially in the context of special needs engagement. Investigating three successive cohorts provides an opportunity to capture a trajectory of learning: from initial awareness and empathy, to skill development and confidence, and ultimately to leadership and advocacy. Such a developmental pathway reflects the natural progression of transformative learning and the maturation of educational programs through continuous improvement.

3.0 Methodology

3.1 Study Design

This study employed a qualitative comparative design using thematic analysis of reflective writings from three consecutive cohorts of final-year undergraduate dental students. The design allowed exploration of how learning experiences evolved as the community engagement program matured over three years.

3.2 Setting and Participants

The study was conducted at the Faculty of Dentistry, Universiti Teknologi MARA (UiTM), Sungai Buloh, Malaysia. All final-year students enrolled in the Paediatric and Special Care Dentistry course between 2023 and 2025 participated in the mandatory community engagement program. A total of 240 students (Cohort 1 = 80; Cohort 2 = 82; Cohort 3 = 78) were included. Participation in the learning activity was compulsory; however, consent was obtained to use their anonymised reflections for research purposes.

3.3 Description of the Community Engagement Program

The program was designed to integrate classroom instruction with authentic community service in alignment with UiTM's Service Learning Malaysia – University for Society (SULAM) initiative. Students were grouped into teams and assigned to community institutions catering to individuals with special needs (IWSN), such as children with developmental disorders, adolescents with intellectual disabilities, and older adults requiring assisted living.

Each student group undertook four sequential phases:

1. **Preparation:** Pre-visit lectures on behaviour management, oral hygiene care, communication, and oral-health needs of IWSN.
2. **Planning:** Team development of oral-health education and screening activities under academic supervision.
3. **Implementation:** One-day outreach visit to the assigned institution to conduct educational games, oral-health demonstrations, and basic screening with IWSN and their caregivers.
4. **Reflection:** Individual reflective report submission describing personal insights, challenges, and perceived professional growth.

Table 1. Comparison of the preparation and reflection tools across the three different cohorts

Component	Cohort 1(2023)	Cohort 2(2024)	Cohort 3(2025)
Preparation	Lecture	Lecture	Lecture
	Hands-on workshop	Hands-on workshop – additional workshop and	Hands-on workshop – additional
	Briefing session	behaviour management technique	workshop and behaviour management and communication technique
		Briefing session	Briefing session
Reflection tool	Open-ended prompt	Structured template	Structured and guided debrief discussion
		Peer assessment evaluation	Peer assessment evaluation
Focus of Engagement	Exposure and empathy	Skill application	Leadership, professionalism, advocacy for inclusivity

3.4 Data Collection

Each student submitted an individual reflective essay (800–1000 words) immediately after program completion. Reflection prompts were adapted from Ahmad et al. (2015) to elicit learning about professional skills, attitudes, and societal awareness. All reflections were anonymised, coded, and stored securely. Students are also required to confidentially rate their own and their teammates' contributions, submitting these evaluations directly to the supervisors. This peer-based feedback system encouraged honesty, accountability, and self-reflection while reinforcing teamwork and professionalism in community-based learning.

3.5 Data Analysis

Thematic analysis was conducted following Braun and Clarke's (2006) six-phase framework: familiarisation, initial coding, theme generation, review, definition, and reporting. Two researchers independently analysed the data for each cohort before cross-cohort comparison. Themes were compared to identify progressive shifts in learning outcomes across the three years. Investigator triangulation and peer debriefing were employed to enhance credibility and dependability. Representative quotations were selected to illustrate each theme.

4.0 Findings

A total of 240 reflective essay forms were analysed across three cohorts of final-year dental students who participated in the community engagement program involving individuals with special needs (IWSN).

Thematic analysis revealed three overarching themes representing a progressive development in learning:

1. Awareness and Empathy (Cohort 1)
2. Skill Application and Confidence (Cohort 2)
3. Leadership and Advocacy (Cohort 3)

This evolution reflects how experiential learning deepened over successive program cycles as the activity structure and reflective support matured.

4.1 Theme 1: Awareness and Empathy (Cohort 1 – 2023)

Students in the first cohort described the experience as an eye-opening introduction to individuals with special needs. Most had never interacted directly with this population and expressed surprise, curiosity, and compassion. Their reflections emphasised emotional impact and newfound awareness of societal inequities.

“This was my first encounter with children who have disabilities. It made me realise how different their daily struggles are and how much patience is needed to care for them.” – Cohort 1, Student A.

“I used to feel anxious around special needs individuals, but this visit changed my perception. They deserve the same quality of care as everyone else.” – Cohort 1, Student B.

At this stage, students primarily reflected on feelings rather than skills, focusing on empathy, gratitude, and recognition of the human dimension of dentistry. The learning was affective in nature, marking the beginning of a transformative process.

4.2 Theme 2: Skill application and Confidence

In the second cohort, reflections revealed a shift from emotional awareness to practical application. With the introduction of a more detailed preparatory workshops and structured reflection templates, students reported improved communication and behavioural management skills.

“During the program, I applied the tell-show-do technique I learned in class, and it worked beautifully. It was fulfilling to see the child respond positively.” – Cohort 2, Student D.

“The visit helped me understand that modifying our communication style makes all the difference. I felt more confident engaging with the children and their caregivers.” – Cohort 2, Student E.

Students also highlighted teamwork, problem-solving, and adaptability as key learning outcomes. The focus expanded from self-awareness to professional competence, reflecting the second stage of experiential learning — applying theoretical concepts in authentic contexts.

4.3 Theme 3: Leadership and Advocacy

By the third cohort, students demonstrated the deepest level of reflection. With the addition of guided debriefing sessions and more student-led planning, reflections revealed leadership development, advocacy, and social accountability.

“Leading my group during the visit taught me how to organise, delegate, and motivate others while keeping the patients’ comfort in mind.” – Cohort 3, Student H

“I realised that being a dentist means advocating for those who may not have a voice. Everyone deserves access to oral healthcare.” – Cohort 3, Student J

Students articulated a strong sense of professional identity and purpose. Their reflections indicated transformation from individual empathy to collective responsibility — connecting clinical competence with ethical and societal values.

Table 2. Comparative Summary of Learning Progression

Learning Domain	Cohort 1(2023)	Cohort 2(2024)	Cohort 3(2025)
Primary focus	Awareness and empathy	Skill application and confidence	Leadership & advocacy
Learning nature	Emotional and reflective	Practical & integrative	Transformative & value-driven
Key outcomes	Compassion, patience, respect for diversity	Improved communication, behaviour guidance, teamwork	Leadership, professionalism, advocacy for inclusivity
Representative quote	“It was an eye-opener to the challenges they face.”	“I applied what I learned in lectures during the visit.”	“We must advocate for inclusive care in our community.”

5.0 Discussion

This study examined the evolving reflections of three cohorts of final-year dental students who participated in a community engagement program involving individuals with special needs (IWSN). The findings revealed a clear developmental progression in student learning: from awareness and empathy in the first cohort, to skill application and confidence in the second, and finally to leadership and advocacy in the third. This transformation reflects how experiential learning, when embedded within a supportive and reflective framework, can move students from cognitive understanding to professional identity formation and social responsibility.

5.1 Progressive Learning Through Experience

The shift in themes across cohorts illustrates the natural growth that occurs when experiential learning opportunities are implemented iteratively. Kolb's Experiential Learning Cycle (1984) provides a useful lens to interpret this progression. Cohort 1 primarily engaged in the concrete experience phase, where emotional awareness and empathy dominated their reflections. Cohort 2 advanced into reflective observation and active experimentation, applying theoretical principles such as communication strategies and behaviour management in real-world contexts. Cohort 3 reached abstract conceptualisation, demonstrating an ability to internalise and generalise lessons into broader professional attitudes such as leadership and advocacy.

This trajectory supports previous findings in health professions education, where community-based experiences lead to deeper learning and social awareness when repeated and scaffolded (Angelopoulou & Kavvadia, 2018; Witton & Paisi, 2022). Each cohort benefited not only from their own experiences but also from programmatic refinements introduced after earlier feedback, illustrating how educational innovation evolves through continuous reflection and curriculum enhancement.

5.2 From Empathy to Advocacy: A Transformative Process

The findings indicate that the program did more than provide exposure; it initiated a transformative learning process. According to Mezirow's Transformative Learning Theory (2000), learners shift from unexamined assumptions toward critical self-reflection and new perspectives. Students in Cohort 3 articulated this transformation most clearly, moving beyond compassion for IWSN to recognising their role as future advocates for equitable oral healthcare.

Such development aligns with the goals of where students must integrate empathy with clinical competence and ethical accountability (Ahmad et al., 2020; Naimie et al., 2020). The progression observed represents a maturing of both personal and professional identity. This reinforces the argument that community engagement is not an “add-on” but a core component of holistic dental education.

5.3 Reflection as a Driver of Deeper Learning

The addition of structured reflection tools and debriefing sessions played a critical role in deepening students' learning over time. Reflection enables learners to make meaning of experience, transforming passive participation into active understanding (Schön, 1983; Ng et al., 2021). Cohorts that received guided reflection prompts produced more analytical and self-aware narratives, while earlier open-ended reflections tended to be descriptive. This demonstrates that reflection must be scaffolded, not assumed. Structured reflection encourages students to question assumptions, evaluate responses, and consider their future professional roles. It also provides educators with valuable data to improve curriculum design and assess the affective outcomes of learning.

5.4 Community Engagement as a Bridge from Classroom to Society

The outcomes of this study exemplify the philosophy of SULAM, which positions community engagement as a bridge between academic learning and civic contribution. Through this program, students learned not only to serve but also to understand the structural and emotional barriers faced by individuals with disabilities.

By participating directly in outreach activities, students transformed theoretical knowledge into socially relevant practice, aligning with UiTM's vision of developing graduates who are compassionate, competent, and community-oriented. The evolution from classroom instruction to community impact echoes the CSSR 2025 theme, "From Classrooms to Society." It reinforces that higher education institutions must cultivate socially responsible graduates who contribute meaningfully to inclusive public health.

5.5 Educational Implications

The progressive nature of findings across cohorts underscores the importance of curricular continuity and feedback loops in experiential education. When community engagement programs are reviewed and refined annually—through structured reflection, student feedback, and faculty evaluation—they produce increasingly sophisticated learning outcomes.

Educators should therefore integrate community engagement as a longitudinal thread within dental curricula, beginning early in training and culminating in leadership-oriented projects. Moreover, collaboration between dental schools and community institutions should be sustained, ensuring mutual benefit and ongoing opportunities for student learning, research, and advocacy.

5.6 Limitations and Future Directions

While this study offers valuable longitudinal insights, it relies on self-reported reflections, which may be subject to social desirability bias. Future research could triangulate findings using focus group discussions, supervisor observations, or validated assessment tools measuring empathy and professionalism. Quantitative evaluation of pre- and post-engagement attitudes toward IWSN would also complement the qualitative data. Further exploration could investigate how these experiential experiences influence graduates' actual clinical behaviours and willingness to treat special needs patients in their professional practice, thus evaluating the long-term societal impact of community-based education.

6.0 Conclusion& Recommendations

This three-year study demonstrates that structured community engagement progressively transforms dental students' learning from awareness and empathy to leadership and advocacy. Experiential exposure to individuals with special needs (IWSN) nurtures professionalism, communication, and social responsibility—bridging academic learning with societal contribution.

It is recommended that community engagement be integrated longitudinally within the dental curriculum, supported by preparatory workshops, guided reflection, and debriefing. Continuous program evaluation and collaboration with community partners will sustain meaningful learning, ensuring that future dental graduates emerge as competent, compassionate, and socially accountable practitioners.

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Paper Contribution to the Related Field of Study

This study contributes to the growing body of evidence on experiential and community-based learning in dental education. By analysing reflections from three consecutive student cohorts, it demonstrates how structured community engagement with individuals with special needs (IWSN) fosters a developmental progression from awareness to advocacy.

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Development and Content Validation of a Dual-Audience Tool to Guide Parental Interventions for Reducing Children's Dental Anxiety

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Abstract

Early dental experiences significantly shape a child's perception of oral healthcare. Parental involvement and preparation are critical in reducing dental anxiety during the first dental visit. This study aimed to develop and validate a focus group discussion (FGD) items to inform the design of a parental guidance module for reducing children's dental anxiety. A six-member expert panel (two paediatric dentists, two public health specialists, two general dentists) assessed content and face validity using a 4-point scale. Items rated below 2 were revised or removed. The final version achieved a Scale-level CVI (S-CVI) of 0.96, demonstrating high clarity, appropriateness, and reliability.

Keywords: dental anxiety; parental guidance; FGD items; paediatric dentistry

1.0 Introduction

Early dental experiences play a crucial role in shaping a child's perception of dental care and long-term attitude towards oral healthcare. Dental anxiety during these early encounters is a common behavioural issue that can adversely impact treatment success and result in dental avoidance into adolescence and adulthood (Klingberg & Broberg, 2007).

Studies have reported that the global prevalence of dental anxiety in children ranges from 5% to 20%, influenced by age, cultural background, and assessment tools (Cianetti et al., 2017). It can manifest as crying, refusal to open the mouth, restlessness, or even psychosomatic symptoms before dental appointments (Klingberg & Broberg, 2007). When left unaddressed, dental anxiety can lead to avoidance behavior, delayed dental care, and increased risk of caries and poor oral health outcomes (Rantavuori et al., 2004).

Among the modifiable contributors to dental anxiety, parental influence plays an important role. Parents not only model attitudes towards dental care, but are instrumental in emotionally preparing children for their first dental visit (Aminabadi et al., 2011) (Cuthbert & Melamed, 1982). Despite this, many parents report limited access to reliable resources or tools to effectively prepare their children for this significant event, leading to increased anxiety and negative experiences. Parental involvement and education are crucial in shaping a child's attitude towards dental care. While the importance of early dental visits is well established, a significant gap remains in educational resources that effectively support parental preparation before the child's first dental appointment.

This study aims to address this gap by developing and validating a dual-audience items targeted at both parents and dental practitioners. The tool is designed to inform the creation of educational materials or parental guidance tailored for parents, helping them prepare their children for their initial dental visit. The items gathers insights on common concerns, parental expectations, and practical strategies for anxiety reduction. By empowering parents with knowledge and resources, we can enhance the first dental visit experience, fostering a positive relationship between the child and dental care providers.

2.0 Materials and Methods

2.1 FGD Item Development

The items were developed using a structured, qualitative, exploratory design to create a reliable and content-valid tool aimed at assessing awareness, expectations, and experience of parents and dental practitioners in reducing dental anxiety in children during their first dental visit.

A thorough literature review was conducted using databases such as PubMed, Scopus, and Google Scholar to identify existing tools and theoretical frameworks or concepts related to paediatric dental anxiety, behavioural management, parent-dentist communication, and early childhood oral health care. Drawing from this review and expert clinical input, an initial set of items was formulated for two thematically related sections: one for parents and another for dental practitioners. Where relevant, selected items were adapted from validated tools used in paediatric health education contexts. The draft items consisted of 20 items for parents and 12 items for dentists.

The interview guide for parents (Figure 2) included open-ended questions across eight thematic areas, such as prior dental experiences, the child's behavioural responses before and after dental visits, perceived triggers of anxiety, and strategies used at home to manage these anxieties. Participants were also asked about their sources of oral health information and their views on useful educational resources.

In contrast, the interview guide for dental practitioners (Figure 3) focused on their professional background, frequency of encountering child dental anxiety, current behaviour management practices, parental involvement, and feedback on the proposed parental guidance module. Dental practitioners were also invited to suggest improvements for the resource's content and implementation.

2.2 Expert Panel and Content Validity

Content validity was assessed by a panel of six subject matter experts: two paediatric dentists, two general dental practitioners, and two public health specialists (Yusoff, 2019). Experts were selected through purposive sampling based on their professional background, clinical experience of at least five years, and familiarity with paediatric patient management or health education. All were affiliated with academic or clinical institutions in Malaysia.

The experts independently evaluated each item's relevance using a 4-point scale (1 = not relevant, 4 = highly relevant). The Item-level Content Validity Index (I-CVI) was calculated to determine the proportion of experts who rated the item as either 3 or 4. Items with I-CVI values below 0.83 were revised or removed in accordance with expert consensus.

To facilitate this process, an online content validation form (Figure 1) was distributed along with clear rating instructions and domain specific definitions. This non-face-to face approach was adopted to optimize flexibility, time-efficiency, and response rate, as recommended by Yusoff (Yusoff, 2019).

The Scale-level Content Validity Index (S-CVI) was calculated as the average of all I-CVI scores across items. Items that fell below the recommended I-CVI were either revised or omitted based on expert consensus.

The number of experts and its implication on the acceptable cut-off score of CVI

Number of experts	Acceptable CVI values	Source of recommendation
Two experts	At least 0.80	Davis (1992)
Three to five experts	Should be 1	Polit & Beck (2006), Polit et al., (2007)
At least six experts	At least 0.83	Polit & Beck (2006), Polit et al., (2007)
Six to eight experts	At least 0.83	Lynn (1986)
At least nine experts	At least 0.78	Lynn (1986)

FORM FOR CONTENT VALIDATION INDEX (CVI)

Title for the instrument for validation: Development of a Parental Guidance Module to Mitigate Dental Anxiety in Young Children During Their Initial Dental Visit.

Dear Experts:

we request your expert opinion on the relevance of each item is being measured. The instructions are provided below to guide you in your analysis. Please use the following rating scale and rate each item as objective as possible in our review.

Instructions:

This questioner will be used to develop a parental guidance module that can help mitigate dental anxiety in young children during their first dental visit.

please note that there are 2 different questioners one for the parents another for the dentists. you must place the punctuation that you consider appropriate in each question according to the following scale.

you can comment on each question according to the rating.

1. Not Relevant
2. Somewhat relevant
3. Quite relevant
4. Highly relevant

If rating is "1" and "2" please suggest improvement or kindly provide the justification.

Figure 1: Expert content validation form and scoring instructions.

QUESTIONNAIRE FOR PARENTS	SCALE				COMMENT
	1	2	3	4	
1. Understanding Dental Anxiety/general concerns:					
a) What are your main concerns when it comes to your child's dental health?					
b) How do you feel about taking your child to the dentist?					
2. Previous Dental Experience					
a) Can you tell me about your previous experience of your child's dental visit?					
b) How old was your child when you came?					
c) What was the purpose of the visit at that time?					
d) How often do you visit dentist?					
e) Can you describe your child's first dental visit?					
f) How did it go?					
g) Has your child ever expressed fear or anxiety about going to the dentist?					
h) If so, what specifically are they afraid of?					
3. At home reaction to first dental visit					
a) Could you explain how your child reacted before going to see the dentist?					
b) Do you notice any changes in your child's behaviour before and after going for the dental appointment?					
c) What did you do to try and explain the dental visit to your child?					
d) What made it easier for you? Did you encounter any challenges bringing your child to see the dentist for the first time?					

g) Have any family members given you advice about your child's first visit? If so, what did they tell you? Did you follow their advice?					
8. Feedback on Resources:					
a) What kind of information or resources do you think would be most helpful in reducing dental anxiety for your child?					
b) How would you prefer to receive this information (e.g., pamphlets, websites, apps)?					
9. Closing Questions/ final thoughts					
a) Do you have any additional thoughts or suggestions on how to better address dental anxiety in children?					
b) Is there anything else you would like to discuss about this?					
c) Is there anything else you would like to share about your experiences or needs related to your child's dental care?					

4. At dental office reaction to first dental visit					
Could you describe how your child feels having to come to clinic for the first time?					
b) Is there anything your child look forward to about coming to see a dentist?					
c) Is there anything they find upsetting?					
5. Sources of Anxiety/ Triggers					
a) What do you think causes dental fear in your child?					
b) Are there any particular aspects of the dental visit that your child finds most stressful (e.g., the environment, sounds, smells, specific procedures)?					
6. Current way of Managing Anxiety					
a) How do you currently prepare or say to your child before coming for a dental visit?					
b) What strategies have you found to be effective in reducing your child's dental fear? Have you tried searching online to find ways to reduce dental fear for the first time?					
7. Sources of information					
a) Where do you look for information/advice about ways of reducing anxiety for first dental visit?					
b) Are you aware of any educational tools or resources that help manage dental anxiety in children?					
c) Have you used any specific resources or tools to help prepare your child for dental visits?					
d) If so, which ones, and how effective were they?					
e) What did your health advisor tell you about dental anxiety (if anything)?					

Figure 2: Interview guide and open-ended question matrix for parents.

.....
(signature with stamp)

.....
(Date)

QUESTIONNAIRE FOR DENTISTS	SCALE	COMMENTS
A) Introduction and Background		
1. Can you describe your experience and background in paediatric dentistry?		
2. How often do you encounter children with dental anxiety during their first visit?		
B) Current Practices		
1. What strategies do you currently use to help reduce dental anxiety in children?		
2. How do you involve parents in preparing their children for the first dental visit?		
C) Parental Education Kit Components you think would be particularly effective?		
1. In your opinion, what are the most important elements that should be included in a parental education kit to reduce dental anxiety in children?		
2. Are there any specific tools or materials (e.g., videos, activities) that brochures, interactive		
D) Effectiveness and Feasibility		
1. How do you think a parental education kit could impact a child's experience during their first dental visit?		
2. What challenges do you foresee in implementing such a kit in your practice?		
3. How would you measure the success or effectiveness of the parental education kit in reducing dental anxiety?		
E) Feedback and Suggestions		
1. Have you used any similar resources in the past? If so, what was your experience?		

2. Do you have any suggestions for improving the proposed parental education kit?					
3. How can the kit be tailored to meet the diverse needs of different families and children?					
F) Communication with Parents					
1. How do you usually communicate with parents about preparing their children for dental visits?					
2. What information do you think parents need most to help their children feel comfortable during their first dental visit?					
G) Future Perspectives					
1. How do you see the role of parental education evolving in paediatric dentistry?					
2. What additional support or resources would you need to effectively integrate a parental education kit into your practice?					

.....
(signature with stamp)

.....
(Date)

Figure 3: Interview guide and thematic prompts for dental practitioners.

The Scale-level Content Validity Index (S-CVI) was calculated as the average I-CVI across all items. Items with I-CVI <0.83 were revised or removed.

2.3 Face Validity

Experts also reviewed each item for clarity of language, appropriateness, and perceived usefulness for the intended target audience. Their qualitative feedback was systematically analysed and used to revise the phrasing and structure of selected items to enhance clarity and reduce ambiguity.

3.0 Results

The I-CVI scores for individual items ranged from 0.67 to 1.00. The majority of items (81.25%) achieved perfect agreement (CVI = 1.00), indicating strong consensus. Items receiving, I-CVI <0.83 were concentrated in domains related to parental knowledge gaps. Overall, the high S-CVI of 0.96 reflects excellent content validity.

The parent-version items was subjected to expert evaluation by a panel of six reviewers to assess its content validity using the Item-level Content Validity Index (I-CVI). Among the 32 items assessed, the majority (23 items) achieved an I-CVI score of 1.00, indicating unanimous agreement among experts on their relevance and clarity. Six items received, reflecting minor concerns, and were revised accordingly based on expert suggestions. An additional four items scored below the 0.83 threshold (with I-CVI values of 0.67), indicating the need for substantial modification. Of these, two were deemed slightly redundant and removed. One item received feedback regarding its excessive length and was separated into two distinct items to improve clarity. These findings suggest that while the majority of the items were considered acceptable without modification, expert feedback was essential in refining several items to enhance the overall clarity, relevance, and structure of the items.

The content validity of the items developed for dental practitioners was evaluated using the Item-level Content Validity Index (I-CVI), based on assessments from six expert reviewers. Out of the 16 items evaluated, 14 items achieved an I-CVI score of 1.00, reflecting complete agreement among experts regarding their relevance and clarity. Only two items received a slightly lower score of 0.83, suggesting minor concerns related to clarity. This item was subsequently revised in accordance with the experts'

feedback. Overall, the results indicate a high level of content validity, with the vast majority of items demonstrating strong consensus among experts and requiring no further modification. Overall, the high S-CVI of 0.96 reflects excellent content validity.

Table 1. Content Validity Index (CVI) Ratings for the parent's items

ITEM	CVR	CVI	Expert Feedback	Action taken
Q1 a	6	1	Acceptable	Retained
Q1 b	6	1	Acceptable	Retained
Q2a	6	1	Acceptable	Retained
Q2b	4	0.67	Not Clear	Revised
Q2c	6	1	Acceptable	Retained
Q2d	4	0.67	Slightly redundant	Removed
Q2e	5	0.83	Not clear	Revised
Q2f	4	0.67	Slightly redundant	Removed
Q2g	6	1	Acceptable	Retained
Q2h	6	1	Acceptable	Retained
Q3a	6	1	Acceptable	Retained
Q3b	6	1	Acceptable	Retained
Q3c	6	1	Acceptable	Retained

Q3d	5	0.83	Too long	Separated
Q4a	6	1	Acceptable	Retained
Q4b	6	1	Acceptable	Retained
Q4c	6	1	Acceptable	Retained
Q5a	6	1	Acceptable	Retained
Q5b	6	1	Acceptable	Retained
Q6a	6	1	Acceptable	Retained
Q6b	6	1	Acceptable	Retained
Q7a	6	1	Acceptable	Retained
Q7b	6	1	Acceptable	Retained
Q7c	6	1	Acceptable	Retained
Q7d	6	1	Acceptable	Retained
Q7e	6	1	Acceptable	Retained
Q7f	4	0.67	Too long and Not Clear	Separated and rephrased
Q8a	6	1	Acceptable	Retained

Q8b	5	0.83	Not Clear	Revised
Q9a	5	0.83	Not Clear	Revised
Q9b	5	0.83	Not Clear	Revised
Q9c	6	1	Acceptable	Retained

Table 2. Content Validity Index (CVI) Ratings for the items for Dentists

ITEM	CVR	CVI	Expert Feedback	Action taken
QA 1	5	0.83	Not Clear	Revised
QA 2	6	1	Acceptable	Retained
QB1	6	1	Acceptable	Retained
QB 2	6	1	Acceptable	Retained
QC 1	6	1	Acceptable	Retained
QC 2	6	1	Acceptable	Retained
QD 1	6	1	Acceptable	Retained
QD 2	6	1	Acceptable	Retained
QD 3	5	0.83	Not Clear	Revised
QE 1	6	1	Acceptable	Retained
QE 2	6	1	Acceptable	Retained
QE 3	6	1	Acceptable	Retained
QF 1	6	1	Acceptable	Retained
QF 2	6	1	Acceptable	Retained
QG 1	6	1	Acceptable	Retained
QG 2	6	1	Acceptable	Retained

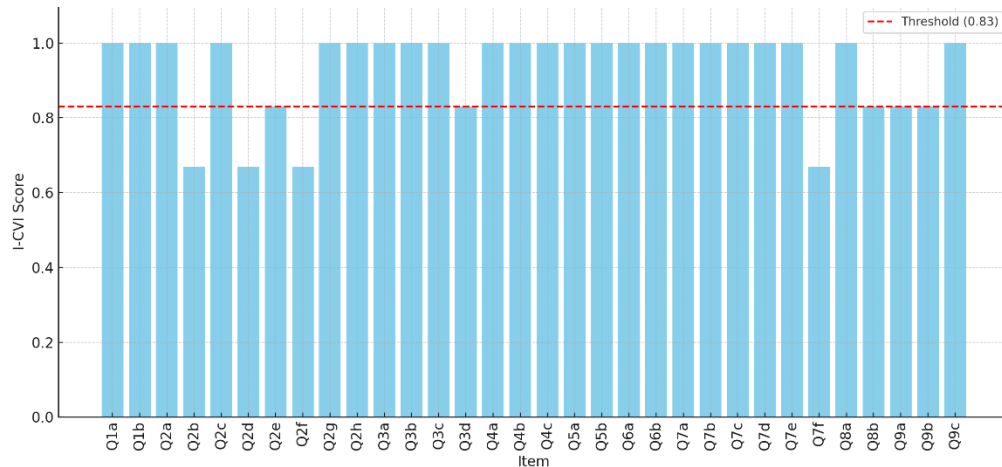


Figure 4:

Distribution of I-CVI Scores -Parents Items

Figure 4 illustrates the distribution of Item-level Content Validity Index (I-CVI) scores for items item of Parents. The distribution of Item-Level Content Validity Index (I-CVI) scores for each item in the items. The majority of items achieved the maximum I-CVI score of 1.00, indicating full agreement among experts regarding their relevance. A red dotted line at 0.83 represents the commonly accepted threshold for item inclusion in content validation.

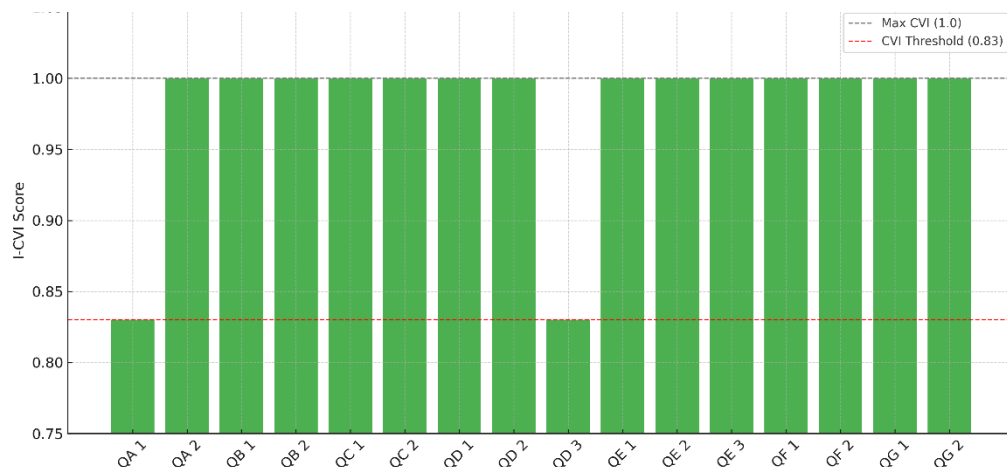


Figure 5: Distribution of I-CVI Scores -Dentists Items

Figure 5 illustrates the distribution of Item-level Content Validity Index (I-CVI) scores For items item of Dentists. Most items achieved the maximum score of 1.0, indicating high agreement among experts regarding content relevance. Items QA1 and QD3 scored 0.83, meeting the minimum acceptable threshold.

4.0 Discussion

The study successfully developed a preliminary items addressing key thematic areas related to parental roles in mitigating children's dental anxiety. Content validation through expert review demonstrated acceptable content validity indices (I-CVI and S-CVI), indicating that the items were generally considered relevant and representative of the construct being measured.

The high CVI scores demonstrate strong expert consensus on the relevance of the items. The revision of items with lower I-CVI values ensured the tool's overall quality and alignment with the study objective. The dual-audience design allows insight into both parental and professional perspectives, which is crucial in constructing an effective guidance module. Compared to existing tools, this tool uniquely addresses the pre-visit phase and focuses specifically on anxiety reduction strategies.

The CVI values obtained in this study meet the commonly recommended thresholds (e.g., I-CVI ≥ 0.78 , S-CVI/Ave ≥ 0.90), suggesting that the items were judged to be both relevant and adequately reflective of the intended domains. This supports the content validity of the tool, which is a critical initial step in instrument development as emphasized by (Lynn, 1986), (Polit & Beck, 2006), and (Yusoff, 2019).

These findings are consistent with similar content validation studies in health sciences, such as those by Hadie et al. (2017) and Ozair et al. (2017), who employed expert panels and non-face-to-face validation processes to establish strong content validity of assessment tools. The use of an online validation form with clearly defined domains and rating instructions, as recommended by Yusoff (2019), may have contributed to the high level of agreement among the expert panel. One notable strength of this study is the use of a structured, non-face-to-face content validation approach, which allowed flexibility and reduced logistical constraints for expert participation. Providing clear definitions and scoring instructions helped maintain consistency and clarity across reviewers.

Despite its strengths, the study's limitations include the lack of construct validation and reliability testing, which will be addressed in the next phase of research. Future studies should also pilot the items in a clinical population to evaluate psychometric properties and practical feasibility.

This content-validated tool may serve as a foundational tool for identifying key parental concerns and behaviours related to children's dental anxiety. It could guide the development of targeted educational interventions or modules to support parents during initial dental visits. Future phases of the study will involve pilot testing the tool among a sample of parents to assess reliability and factor structure. Additionally, translation and cross-cultural validation will be done to adapt the tool for wider use in diverse settings. In conclusion, this study presents the initial development and content validation of a dual-audience tool designed to explore key parental concerns and professional insights related to managing children's dental anxiety during their first dental visit. The tool demonstrated a strong content and face validity, as confirmed by expert consensus, and holds potential for guiding and supporting the creation of targeted parental guidance modules aimed at reducing dental anxiety in children, potentially contributing to improved dental experiences and reduced anxiety among young patients.

While the findings indicate that the tool was relevant, clear, and appropriate for the intended audience, further validation is essential. Future research should focus on pilot testing the instrument in a clinical population to evaluate its reliability, internal consistency, and construct validity. Cross-cultural adaptation and translation may also enhance its applicability in diverse populations.

Once fully validated, the tool can serve as an integral component of comprehensive anxiety reduction strategies in paediatric dental settings, supporting both clinical and educational efforts to improve the first dental visit experience for children and their caregivers.

5.0 Conclusion and recommendations

This study marks the initial phase of developing and validating a dual-audience questionnaire addressing parental and professional perspectives on managing children's dental anxiety during their first dental visit. The strong content and face validity indices reflect high expert consensus on the clarity and relevance of the items, supporting the tool's potential as a reliable foundation for parental guidance interventions.

Further research should focus on pilot testing to establish reliability, internal consistency, and construct validity, followed by translation and cross-cultural adaptation to broaden its applicability.

Recommendations:

- Develop a structured parental guidance module based on the validated questionnaire to enhance children's cooperation and reduce first-visit anxiety.
- Integrate parent-focused strategies within behaviour management protocols to promote early positive dental experiences.
- Use the validated tool to identify parental needs, guide tailored interventions, and foster long-term positive dental attitudes and preventive care behaviours.

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The authors express their sincere appreciation to Universiti Teknologi MARA (UiTM), Malaysia, for the institutional support and research facilitation provided throughout this study. Gratitude is also extended to the Ministry of Health, Republic of Maldives, for their collaboration and valuable contribution toward advancing paediatric oral health research. Their combined support was instrumental in the successful completion of this study and in promoting cross-institutional efforts to improve children's dental experiences through evidence-based parental guidance initiatives.

Paper Contribution to Related Field of Study

This study contributes to paediatric dental research by developing and validating a dual-audience questionnaire that explores both parental and professional perspectives on managing dental anxiety in young children. By focusing on the pre-visit phase, it highlights the critical role of parental preparation in shaping children's first dental experiences. The validated tool provides an evidence-based foundation for designing structured parental guidance modules aimed at reducing anxiety and improving cooperation during early dental encounters. These findings support more holistic, family-centred behaviour management approaches in paediatric dentistry.

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Three-dimensional Morphometric Analysis of Primary Molar Crowns of Children Treated in Faculty of Dentistry, UiTM

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Abstract

This study mapped the three-dimensional morphology of primary molars among children treated at Universiti Teknologi MARA using 3D scanning and digital analysis. A total of 141 models (69 males, 72 females) comprising 644 molars were assessed for mesiodistal, buccolingual, and cuspal height dimensions. Males exhibited significantly taller cusp heights, while mesiodistal and buccolingual widths showed minimal differences. Right-left variations were minor. The generated 3D average shapes provide population-specific references to guide the design of paediatric dental and orthodontic appliances, potentially improving fit and reducing chairside adjustments.

Keywords: Morphometrics, Primary Molar, 3D analysis, Malaysian Children

1.0 Introduction

Dental morphology plays a critical role in oral health, treatment planning, and anthropological research (Hemphill, 2015). In Malaysia, a country with multiple ethnic groups and cultures, children may exhibit tooth size and shape variations across populations (Hussein et al., 2009). These differences are particularly relevant in paediatric dentistry and orthodontics, where clinicians frequently rely on prefabricated stainless steel crowns (SSCs) for restoring extensively decayed primary molars (Innes et al., 2016). Ill-fitting SSCs can lead to gingival inflammation, plaque accumulation, or restoration failure if the crown dimensions do not correspond to the child's tooth morphology (Sharaf & Farsi, 2004).

Most SSCs are designed based on generalised Western population averages. Consequently, Malaysian children may require extensive chairside adjustments during crown placement. Previous studies of Malaysian schoolchildren have primarily focused on two-dimensional (2D) tooth measurements (Hussein et al., 2009). However, linear calliper-based methods cannot capture subtle three-dimensional (3D) variations such as cusp height and contour, which are critical for achieving accurate restorative fit.

Recent developments in 3D scanning have enabled detailed mapping of tooth morphology, providing accurate, reproducible data for morphometric analysis (Gaboutchian et al., 2021). By applying these technologies to primary teeth, clinicians can better understand population-specific dimensions and improve dental appliance design (Choi et al., 2001).

2.0 Literature Review

Tooth morphology represents an important area of study in both clinical and anthropological contexts, as variations in size and shape can influence oral function, treatment planning, and restorative success. In paediatric dentistry, understanding these morphological differences is crucial, as clinicians often rely on prefabricated stainless steel crowns (SSCs) to restore severely

decayed or malformed primary molars. The effectiveness of these restorations relies heavily on how well the crown dimensions match the child's actual tooth morphology.

Most commercially available SSCs are designed based on Western population averages, which may not accurately reflect the dental anatomy of children in other regions, including Southeast Asia. Several studies have highlighted population-specific variation in tooth size and morphology. For example, Hussein et al. (2009) reported measurable differences in tooth size and arch dimensions among Malay schoolchildren compared to other ethnic groups, while Ling and Wong (2007) observed larger crown dimensions in Southern Chinese children. Similarly, investigations involving South Indian, Indonesian Javanese, and Brazilian populations revealed significant inter-population variability in crown widths and cusp heights (Anfe et al., 2012; Eswara et al., 2014; Kuswandari & Nishino, 2004). These findings underscore the need for localised morphometric data to guide the design and selection of restorations that suit specific populations.

Sexual dimorphism in tooth morphology has also been well documented. Males generally exhibit larger teeth than females, attributed to the influence of sex chromosomes and hormonal factors during growth (Alvesalo, 2009). In particular, differences in cusp height and crown contour have been noted in several populations, suggesting that gender-specific reference data may improve the accuracy of paediatric restorative procedures and appliance fabrication.

Earlier studies of tooth morphology relied predominantly on two-dimensional measurements using manual callipers. While informative, these techniques capture only limited aspects of dental anatomy and are prone to parallax and measurement error. In contrast, three-dimensional (3D) digital imaging offers a more accurate and reproducible approach. Gaboutchian et al. (2021) demonstrated how 3D imaging can provide detailed morphometric mapping of teeth, while Liu et al. (2021) confirmed the high validity and reliability of digital measurements compared to conventional methods. The use of 3D scanning technology enables precise evaluation of occlusal topography, cusp morphology, and surface curvature, which are difficult to quantify with traditional tools.

However, despite global advances, there remains a lack of 3D morphometric data on the primary molars of Malaysian children. This gap provides the foundation for the present study, which aims to generate detailed 3D morphometric data and average tooth shapes to support evidence-based design of paediatric dental restorations.

3.0 Methodology

3.1 Study Design and Sample

This cross-sectional morphometric study was conducted at the Faculty of Dentistry, Universiti Teknologi MARA (UiTM), involving dental study models from paediatric patients aged 3–12 years who received treatment at UiTM clinics. Based on institutional records (~8,031 children in the target age range), the sample size was planned using the Krejcie–Morgan formula for finite populations, with a confidence level of 80% and a 5% margin of error, yielding at least 161 samples per molar type (Krejcie & Morgan, 1970). Ethical approval was obtained from the UiTM Research Ethics Committee (FRC/04/2024 (ERP/EX/14/17)(40)).

The eligibility criteria were as follows:

Inclusion criteria: Fully erupted first and/or second primary molars and study models of adequate quality.

Exclusion criteria: Extensive restorations or crowns; evident caries, fracture, hypoplasia, erosion, or severe attrition that could alter the native crown form; and broken/warped models.

After screening, 141 study models (69 boys, 72 girls) were eligible, yielding 644 first and second primary molars for analysis (nominally 161 each of maxillary first, maxillary second, mandibular first, and mandibular second molars).

3.2 3D Scanning and File Preparation

Models were scanned using a Revopoint Mini 3D scanner with standardised calibration and occlusal plane orientation. Meshes were generated in RevoScan (v5.4.2) and exported as STL files. Individual primary molars were digitally segmented in MeshMixer

(v3.5) using polygonal selection to isolate crown surfaces while excluding adjacent teeth and gingiva. Segmented crowns were saved as separate STL datasets for metric analysis.

3.3 Measurement Protocol

All measurements were performed in MeshLab (2023.12) by a single, calibrated investigator. Measurement landmarks captured crown width and cusp/vertical heights(Figures 1-10):

- Point A (Mesiodistal width): maximum mesiodistal distance between contact points, parallel to the occlusal plane.
- Points B-D (Buccolingual widths): buccolingual distance through mesial cusps (B), mid-crown grooves/ridges (C), and distal cusps (D).
- Points E-G (buccal cusp heights): mesiobuccal cusp height (E), buccal groove height (F), distobuccal cusp height (G), measured vertically from standardised gingival margins to cusp/groove peaks.
- Points H-J (lingual/palatal cusp heights): mesiolingual/palatal cusp height (H), lingual/palatal groove height (I), distolingual/palatal cusp height (J).

Teeth were oriented to minimise parallax, and cusp tips/groove summits were identified from multi-angle views.

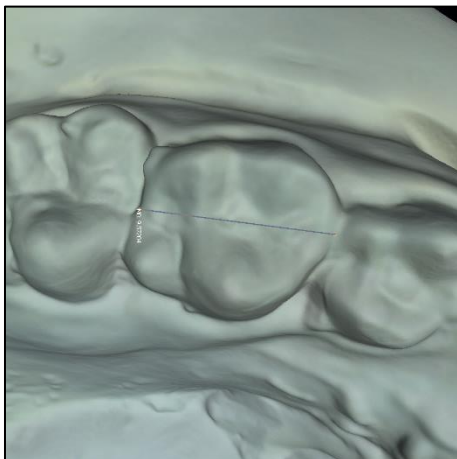


Figure 1: Mesiodistal width (Point A)

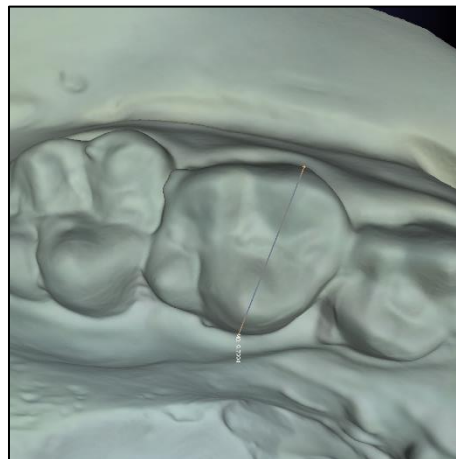


Figure 2: Mesiobuccal-mesiolingual width (Point B)

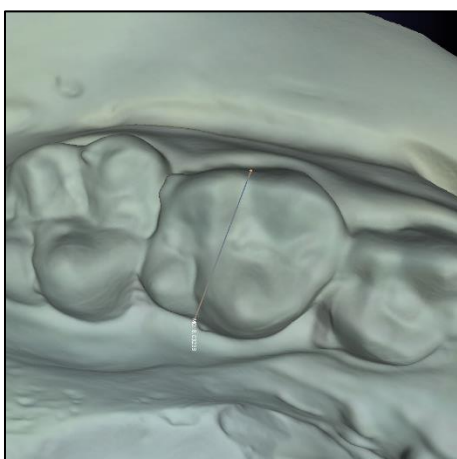


Figure 3: Mid-buccolingual width (Point C)

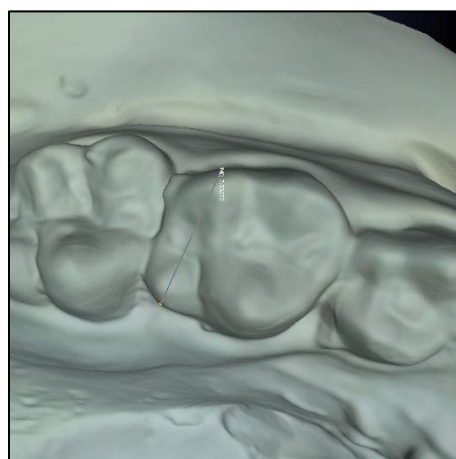


Figure 4: Distobuccal-distolingual width (Point D)

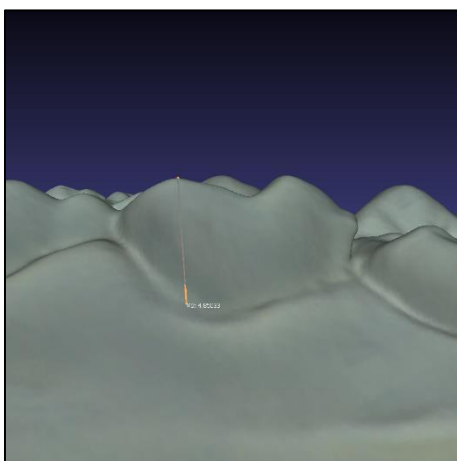


Figure 5: Mesiobuccal cusp height (Point E)

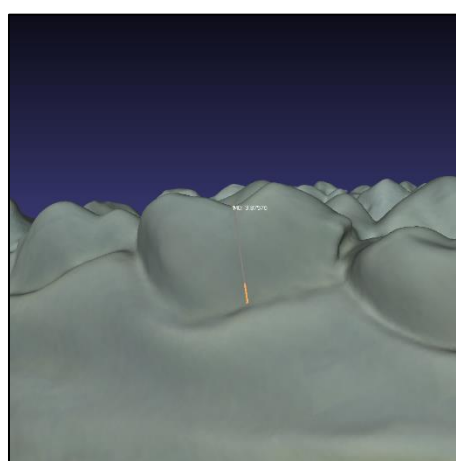


Figure 6: Buccal groove height (Point F)

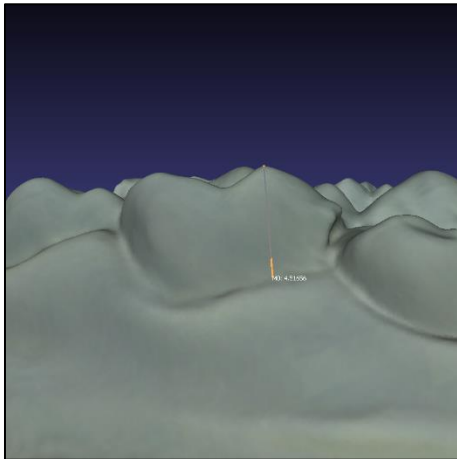


Figure 7: Distobuccal cusp height (Point G)

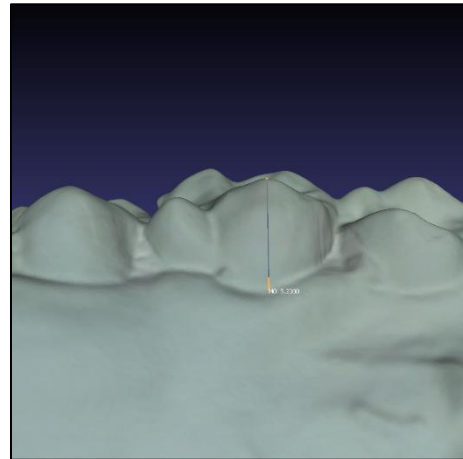


Figure 8: Mesiolingual/Palatal cusp height (Point H)

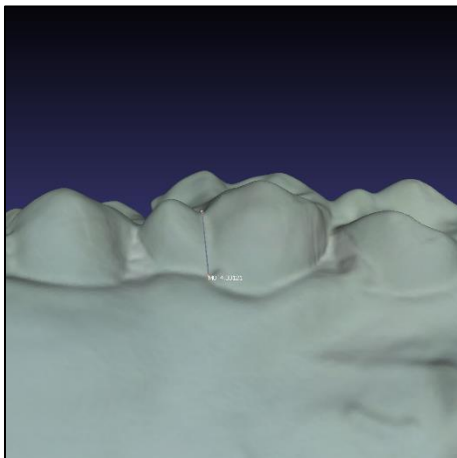


Figure 9: Lingual/Palatal groove height (Point I)

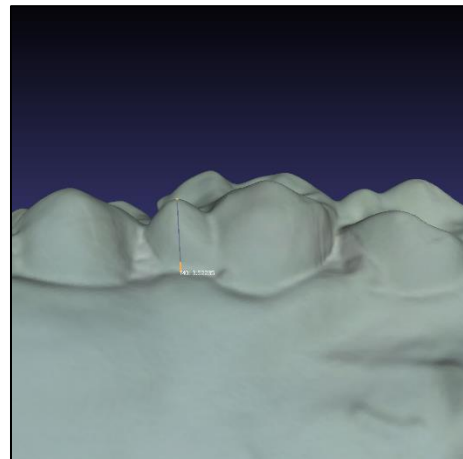


Figure 10: Distolingual/Palatal cusp height (Point J)

3.4 Reliability and Calibration

The measurer (NHUZ) underwent calibration against a gold-standard reference (MAMZA) using 10 standardised models with repeated practice and discussion until discrepancy was ≤ 0.2 mm (6). Inter-operator reliability was evaluated using intraclass correlation coefficients (ICCs), with $ICC > 0.80$ considered good reliability. For intra-operator consistency, 10 randomly selected teeth were re-measured after two weeks, and ICCs for all dimensions exceeded 0.80.

3.5 3D Shape Averaging

For each molar type, STL crowns were co-aligned in MeshMixer along consistent occlusal and fissure references. The models were then blended using the “Attract” function, combining individual meshes into a composite average 3D crown capturing mean cusp profiles, occlusal contours, and marginal ridge form (Figure 11).

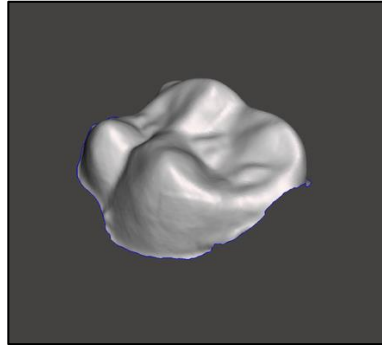


Figure 11: An example of an isolated crown of upper right primary second molar

3.6 Statistical Analysis

Analyses were conducted in SPSS v27 (IBM Corp.). Normality was assessed using the Kolmogorov–Smirnov test. Independent t-tests were used to compare gender differences and right vs left differences within the arches, with $p < 0.05$ as the significance threshold.

4.0 Findings

A total of 141 study models (69 boys, 72 girls; ages 3–12) were analysed, comprising 644 fully erupted first and second primary molars. All linear measurements were performed by a single calibrated examiner, with ICCs > 0.80 across repeated assessments, indicating good to excellent reliability across dimensions.

4.1 Measurement of right and left upper first primary molars according to gender

Across genders, MD (A) and BL widths (B–D) were broadly similar. Differences emerged chiefly in vertical/cusp metrics: on the right side, boys exhibited taller mesiobuccal cusps (E) than girls ($p = 0.018$), and higher distopalatal cusp heights (J) ($p = 0.027$). On the left, J was also greater in boys ($p = 0.021$). Other cusp/groove measures for these teeth were not significantly different by gender (Table 1).

Table 1. Measurement of right (URD) and left (ULD) upper first primary molars according to gender

POINT	MEAN (SD) OF URD		Sig.	MEAN (SD) OF ULD		Sig.
	MALE	FEMALE		MALE	FEMALE	
A	6.646 (0.589)	6.474 (0.553)	0.174	6.592 (0.576)	6.451 (0.604)	0.297
B	7.628 (0.916)	7.375 (0.676)	0.159	7.745 (0.699)	7.676 (0.686)	0.665
C	7.787 (0.564)	7.895 (0.725)	0.444	7.733 (0.661)	7.970 (0.796)	0.158

D	6.765 (0.512)	6.550 (0.601)	0.081	6.532 (0.704)	6.541 (0.646)	0.951
E	4.733 (0.587)	4.427 (0.567)	0.018*	4.707 (0.666)	4.621 (0.731)	0.593
F	3.619 (0.625)	3.566 (0.55)	0.682	3.659 (0.545)	3.655 (0.641)	0.980
G	2.960 (0.572)	2.860 (0.485)	0.394	3.075 (0.645)	3.024 (0.684)	0.739
H	3.682 (0.617)	3.57 (0.638)	0.417	3.725 (0.525)	3.681 (0.528)	0.717
I	3.317 (0.68)	3.124 (0.646)	0.189	3.270 (0.559)	3.083 (0.492)	0.125
J	3.139 (0.735)	2.814 (0.565)	0.027*	3.108 (0.708)	2.766 (0.552)	0.021*

* p < 0.05 indicating statistical significance

4.2 Measurement of Upper Second Primary Molars According to Gender

MD and BL widths showed no consistent gender differences. Vertical/cusp differences again dominated: for the right molar, buccal groove height (F) was greater in boys (p = 0.047). For the left molar, boys showed higher mesiobuccal cusp height (E) (p = 0.004), palatal groove height (I) (p = 0.012), and distopalatal cusp height (J) (p = 0.019) (Table 2).

Table 2. Measurement of right (URE) and left (ULE) upper second primary molars according to gender

POINT	MEAN (SD) OF URE		Sig.	MEAN (SD) OF ULE		Sig.
	MALE	FEMALE		MALE	FEMALE	
A	9.081 (0.529)	8.893 (0.62)	0.143	9.08 (0.576)	8.934 (0.447)	0.219
B	9.211 (0.672)	8.926 (0.724)	0.069	9.337 (0.559)	9.166 (0.677)	0.222
C	9.185 (0.568)	9.233 (0.627)	0.718	9.231 (0.536)	9.256 (0.566)	0.842
D	8.319 (0.772)	8.281 (0.845)	0.834	8.507 (0.735)	8.431 (0.787)	0.660
E	4.477 (1.07)	4.092 (0.652)	0.055	4.418 (0.542)	4.054 (0.554)	0.004*
F	4.185 (0.493)	3.948 (0.571)	0.047*	4.261 (0.599)	4.059 (0.513)	0.117

G	4.286 (0.586)	4.329 (0.566)	0.742	4.373 (0.607)	4.322 (0.495)	0.687
H	4.9 (0.538)	4.772 (0.42)	0.237	4.991 (0.872)	4.78 (0.439)	0.192
I	3.899 (0.58)	3.687 (0.577)	0.102	4.063 (0.708)	3.717 (0.433)	0.012*
J	3.774 (0.715)	3.499 (0.716)	0.086	3.951 (1.089)	3.474 (0.532)	0.019*

* p < 0.05 indicating statistical significance

4.3 Measurement of Lower First Primary Molars According to Gender

No gender differences reached significance for MD or BL widths. On the left side, boys displayed greater mesiolingual cusp height (H) ($p = 0.022$) and distolingual cusp height (J) ($p = 0.048$), the right molar did not differ significantly by gender across measured points (Table 3).

Table 3. Measurement of right (LRD) and left (LLD) lower first primary molars according to gender

POINT	MEAN (SD) OF LRD		Sig.	MEAN (SD) OF LLD		Sig.
	MALE	FEMALE		MALE	FEMALE	
A	7.866 (0.644)	7.751 (0.531)	0.385	7.868 (0.719)	7.744 (0.601)	0.406
B	6.354 (0.927)	6.385 (0.840)	0.876	6.426 (0.826)	6.313 (0.685)	0.506
C	6.772 (0.690)	6.858 (0.725)	0.593	6.700 (0.817)	6.684 (0.645)	0.921
D	5.970 (0.676)	5.881 (0.637)	0.547	6.084 (0.792)	5.781 (0.664)	0.067
E	5.190 (0.668)	5.121 (0.654)	0.646	5.312 (0.542)	5.215 (0.557)	0.437
F	3.819 (0.649)	3.927 (0.490)	0.395	3.906 (0.500)	3.764 (0.468)	0.193
G	3.299 (0.623)	3.288 (0.605)	0.934	3.390 (0.609)	3.158 (0.487)	0.062
H	3.635 (0.749)	3.438 (0.604)	0.193	3.637 (0.677)	3.326 (0.514)	0.022*
I	2.627 (0.644)	2.389 (0.518)	0.068	2.544 (0.538)	2.354 (0.523)	0.115

J	2.692 (0.650)	2.587 (0.628)	0.466	2.766 (0.563)	2.523 (0.519)	0.048*
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* p < 0.05 indicating statistical significance

4.4 Measurement of Lower Second Primary Molars According to Gender

While width measures remained comparable between genders, vertical/cusp metrics were again informative: on the right, boys had higher mesiobuccal cusp height (E) ($p = 0.035$). Distolingual cusp height (J) was higher in boys on both sides ($p = 0.001$ each) (Table 4).

Table 4. Measurement of right (LRE) and left (LLE) lower first primary molars according to gender

POINT	MEAN (SD) OF LRF		Sig.	MEAN (SD) OF LLE		Sig.
	MALE	FEMALE		MALE	FEMALE	
A	9.914 (0.623)	9.634 (0.579)	0.051	10.099(0.463)	9.891 (0.615)	0.080
B	7.960 (0.679)	7.866 (0.784)	0.586	7.838 (0.639)	7.933 (0.581)	0.469
C	8.727 (0.560)	8.622 (0.763)	0.505	8.496 (0.522)	8.627 (0.684)	0.321
D	7.876 (0.660)	7.567 (0.689)	0.055	7.584 (0.869)	7.743 (0.836)	0.387
E	4.602 (0.670)	4.275 (0.626)	0.035*	4.559 (0.651)	4.509 (0.536)	0.693
FM	4.466 (0.486)	4.295 (0.548)	0.163	4.469 (0.405)	4.390 (0.438)	0.383
FD	3.421 (0.474)	3.278 (0.425)	0.179	3.446 (0.465)	3.418 (0.447)	0.776
G	4.597 (0.576)	4.414 (0.500)	0.150	4.609 (0.473)	4.424 (0.478)	0.072
H	3.584 (0.643)	3.498 (0.560)	0.546	3.692 (0.625)	3.538 (0.560)	0.225
I	2.915 (0.474)	2.693 (0.607)	0.088	2.997 (0.540)	2.888 (0.484)	0.321
J	3.738 (0.674)	3.241 (0.611)	0.001*	3.806 (0.490)	3.450 (0.506)	0.001*

* p < 0.05 indicating statistical significance

4.5 Comparison of Upper and Lower First Primary Molars by Sides

For the first molars, in the maxillary first molar, mesial BL width (B) was larger on the left (7.677 ± 0.643 mm) than the right (7.474 ± 0.764 mm), $p = 0.006$. In the mandibular first molar, mid-BL width (C) was greater on the right (6.829 ± 0.665 mm) than the left (6.644 ± 0.706 mm), $p = 0.012$. Other comparisons of the first-molar side were not significant (Table 5).

Table 5. Measurement of upper and lower first primary molars according to side

POINT	MEAN (SD) OF UPPER D		Sig.	MEAN (SD) OF LOWER D		Sig.
	RIGHT	LEFT		RIGHT	LEFT	
A	6.513 (0.534)	6.546 (0.562)	0.594	7.815 (0.614)	7.794 (0.669)	0.753
B	7.474 (0.764)	7.677 (0.643)	0.006*	6.432 (0.803)	6.344 (0.756)	0.319
C	7.778 (0.649)	7.810 (0.721)	0.677	6.829 (0.665)	6.644 (0.706)	0.012*
D	6.620 (0.549)	6.535 (0.646)	0.243	5.851 (0.616)	5.832 (0.618)	0.803
E	4.615 (0.607)	4.688 (0.689)	0.229	5.194 (0.623)	5.224 (0.563)	0.642
F	3.593 (0.588)	3.677 (0.592)	0.262	3.888 (0.579)	3.809 (0.492)	0.227
G	2.927 (0.542)	3.066 (0.659)	0.077	3.326 (0.646)	3.211 (0.513)	0.126
H	3.589 (0.675)	3.701 (0.521)	0.127	3.509 (0.695)	3.435 (0.632)	0.257
I	3.213 (0.696)	3.203 (0.508)	0.914	2.495 (0.616)	2.373 (0.538)	0.126
J	2.981 (0.696)	2.985 (0.604)	0.961	2.646 (0.667)	2.589 (0.575)	0.478

* $p < 0.05$ indicating statistical significance

As for the second molars, maxillary second molars showed no significant side differences across points ($p > 0.05$), suggesting high symmetry. In mandibular second molars, MD width (A) was greater on the left (9.992 ± 0.533 mm) than the right (9.806 ± 0.625 mm), $p < 0.001$ (Table 6).

Table 6. Measurement of upper and lower second primary molars according to side

POINT	MEAN (SD) OF UPPER F		Sig.	MEAN (SD) OF LOWER F		Sig.
	RIGHT	LEFT		RIGHT	LEFT	
A	9.010 (0.572)	9.035 (0.517)	0.621	9.806 (0.625)	9.992 (0.533)	<0.001*
B	9.153 (0.681)	9.237 (0.643)	0.232	7.938 (0.681)	7.891 (0.625)	0.600
C	9.280 (0.566)	9.238 (0.541)	0.515	8.754 (0.551)	8.604 (0.602)	0.055
D	8.302 (0.792)	8.478 (0.749)	0.103	7.689 (0.698)	7.699 (0.886)	0.918
E	4.321 (0.955)	4.253 (0.602)	0.501	4.466 (0.626)	4.494 (0.603)	0.667
F	4.106 (0.525)	4.174 (0.593)	0.253	3.329 (0.451)	3.391 (0.466)	0.290
G	4.320 (0.586)	4.352 (0.570)	0.668	4.506 (0.557)	4.494 (0.516)	0.882
H	4.849 (0.513)	4.860 (0.753)	0.900	3.539 (0.593)	3.565 (0.618)	0.691
I	3.781 (0.604)	3.853 (0.591)	0.274	2.799 (0.517)	2.893 (0.514)	0.105
J	3.614 (0.761)	3.713 (0.949)	0.357	3.484 (0.698)	3.587 (0.532)	0.154

* p < 0.05 indicating statistical significance

4.6 Averaged 3D Shape of Primary Molars

Composite meshes produced for each molar type revealed consistent occlusal topographies and cusp arrangements that visually paralleled the statistical findings: compared with girls, boys tended toward taller cusp apices on several molar types, whereas MD and BL breadths were broadly comparable between sexes. These averaged shapes constitute practical reference models for design and teaching (Figure 12).

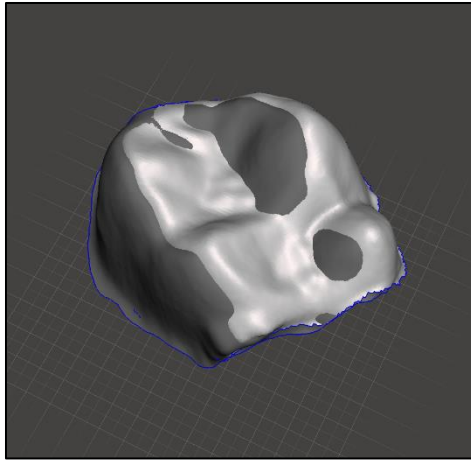


Figure 12: An example rendering of the averaged 3D shape of the upper right primary second molar

5.0 Discussion

This 3D morphometric analysis of Malaysian children's primary molars demonstrates a clear pattern: sexual dimorphism is more pronounced in cusp/vertical metrics than in overall MD and BL widths, and right-left asymmetry is minimal aside from a few width measures in first molars and the mandibular second molar MD width. These observations align with prior reports that primary-tooth mesiodistal size often varies less between boys and girls than vertical or crown-height traits, which can show measurable dimorphism (Eswara et al., 2014; Harris & Lease, 2005; Hussein et al., 2009).

5.1 Comparison with Other Populations

Regional studies have emphasised the importance of population-specific norms. In Malay schoolchildren, tooth and arch dimensions display variation that cautions against direct adoption of external standards (Hussein et al., 2009). Studies in other populations (e.g., Iranian and Spanish cohorts) have similarly shown that primary molar crown dimensions and occlusal contours differ from manufacturer assumptions for SSCs, with potential effects on seating and marginal fit (Afshar et al., 2015; Barbería et al., 2009; Shahrabi et al., 2019). Our findings echo this theme: boys' higher cusp heights, particularly in distolingual/distopalatal cusps and selected mesiobuccal cusps, suggest that relying only on MD widths to select crowns could miss clinically relevant vertical morphology.

Notably, the side-to-side differences we observed were limited. Maxillary second molars were symmetrical across measured points, and only one BL width in each of the first molars and the MD width in mandibular second molars displayed small but significant asymmetry. Clinically, this indicates that arch symmetry can generally be assumed for most parameters when selecting and adjusting prefabricated components for contralateral teeth. However, modest lateral adjustments may be prudent for the specific widths noted.

5.2 Clinical Implications

From a restorative standpoint, cusp height matters for occlusal clearance, marginal seating, and postoperative comfort. When SSC selection is driven solely by MD fit, hyperocclusion or incomplete coverage is more likely, potentially increasing finishing adjustments and appointment duration—issues that weigh heavily in paediatric behaviour management (Sharaf & Farsi, 2004). The present data support a more nuanced sizing strategy incorporating vertical occlusal morphology (E–J points) in addition to MD/BL widths.

For orthodontic and interceptive appliances (e.g., bands, space maintainers), knowing that widths are relatively stable across sexes while vertical relief can differ guides both selection and chairside contouring. Manufacturers may also consider offering variant

crown profiles tuned to populations with taller average cusps in boys, or supplying adjustable occlusal thickness options to reduce grinding. The averaged 3D shapes provided here can seed CAD-CAM templates for region-appropriate SSCs, band forms, and virtual setups, reducing ad-hoc adjustments and standardising outcomes.

5.3 Advantages of the 3D Workflow

This work leverages a scanner-based 3D pipeline (Revopoint Mini → MeshMixer → MeshLab) to capture occlusal relief and standardise landmarking. Compared with 2D and calliper methods, the protocol mitigates parallax and offers repeatable multi-view landmark identification, reflected in ICC > 0.80 across repeated measurements (Benazzi, 2007; Gaboutchian et al., 2021). The construction of composite average crowns is a practical translational step rarely included in morphometric surveys; these models are readily reusable for undergraduate training, appliance simulation, and future design studies. The cohort size (644 molars) and balanced sex distribution provide a robust descriptive base for the local clinical population.

5.4 Limitations and Future Work

The cohort is derived from patients treated at a single Malaysian centre and may not fully represent the country's ethnic and socioeconomic breadth. By design, only intact, fully erupted molars were included, excluding teeth with severe caries or wear; this enhances morphological fidelity but narrows generalisability to compromised clinical scenarios. Finally, the study is cross-sectional and does not capture age-related morphologic changes during the primary and mixed dentitions.

Future work should expand to multi-centre samples across Malaysia and neighbouring Southeast Asian contexts, incorporate longitudinal tracking, and link morphometrics to clinical outcomes (e.g., SSC longevity, plaque indices, and gingival parameters). A parallel engineering track could use these data to parameterise CAD libraries for SSCs and bands, exploring sex-specific occlusal profiles and thickness options, followed by bench testing and clinical trials to quantify reductions in chairside modification time and improvements in fit.

6.0 Conclusion & Recommendations

In Malaysian primary molars, mesiodistal and buccolingual widths are broadly similar between boys and girls, whereas cusp and vertical heights are consistently greater in boys across several molar types. Right–left differences are small, with isolated exceptions in first-molar BL widths and mandibular second-molar MD width. Average 3D crown shapes distilled from this cohort offer population-specific references for restorative and orthodontic planning. Incorporating these morphometrics—especially vertical relief—into crown and band selection or design may reduce chairside adjustments, improve fit, and enhance paediatric treatment efficiency and comfort.

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Paper Contribution to Related Field of Study

This paper contributes to the field of paediatric dentistry by establishing the first comprehensive 3D morphometric dataset for primary molars of Malaysian children. The study supports advances in digital dental morphology and provides a practical framework for developing population-specific restorative and orthodontic appliance designs in Malaysia and Southeast Asia.

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Effectiveness of Sagittal View Enhanced Video-Based Demonstration on Endodontic Access Cavity in Preclinical Endodontic

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Abstract

Preclinical endodontic training often relies on live demonstrations, but limited visibility reduces student understanding. This study developed a sagittal cross-sectional video using a high-definition dental operating microscope to show real-time internal pulp chamber anatomy. Sixty second-year dental students were randomly divided into live demonstration and video demonstration groups. Students completed pre and post questionnaires and a practical exercise assessed by calibrated examiners. Both groups showed significant improvement after instruction. No significant differences were found between groups in knowledge or performance. Sagittal-view video teaching achieved outcomes comparable to live demonstrations and improved visual learning.

Keywords: Video-based demonstration, Sagittal view, Access cavity preparation, Dental education, Preclinical endodontic

1.0 Introduction

Preclinical dental education bridges theoretical instruction and the clinical mastery required for safe patient care. Students at this stage cultivate psychomotor skills, spatial reasoning, and a conceptual understanding of dental anatomy before treating real patients (Peters, 2004). Before treating actual patients, students at this stage develop psychomotor skills, spatial reasoning, and a conceptual understanding of dental anatomy (Peters, 2004). Endodontics is one of the most challenging disciplines for dental undergraduate students due to its need for precise internal pulp chamber orientation (Vertucci, 2005).

Traditionally, live demonstrations considered the pinnacle of dentistry education, enable students to learn about the sequence and reasoning behind each procedural step. However, these demonstrations are often constrained by physical visibility and time. Only those seated near the instructor have a clear view; subtleties in angulation, pressure, and depth are easily missed. Once performed, the demonstration cannot be repeated at the same fidelity. These shortcomings frequently result in uneven understanding and anxiety when students later attempt the procedure themselves (Alqahtani et al., 2015).

Modern educational philosophies stress active, student-centered, and multimodal learning. Video-based resources provide flexibility and standardization, enabling repeated viewing and self-directed reinforcement (Mayer, 2009). However, most dental procedural videos illustrate only the occlusal or external view, neglecting to illustrate the bur's internal movement through dentine and enamel. The invisible dimension of endodontic anatomy remains cognitively demanding for beginners.

To address this pedagogical gap, the present project developed a sagittal-view, microscope-assisted instructional video showing a longitudinally sectioned tooth during real-time access cavity preparation. By revealing the internal progression of the bur, students can visualize the relationship between external landmarks and internal morphology as never before. This approach combines the authenticity of live performance with the clarity of cross-sectional anatomy, transforming the conventional teaching paradigm.

The objective of this study was to develop this novel sagittal-view instructional video and to evaluate its effectiveness compared to conventional live demonstration (LD) in improving undergraduate students' understanding and practical performance in endodontic access cavity preparation.

2.0 Literature Review

2.1 Visual and Cognitive Demands in Endodontic Education

A sophisticated combination of cognitive reasoning, visual perception, and precise motor control is required for endodontic procedures (Peters, 2004). Access cavity preparation necessitates not only the memorization of external markings but also the

visualization of internal structures that are not visible. The mental mapping of these relationships is a challenge for many novice learners, resulting in procedural errors such as pulp chamber perforation or over-preparation. This challenge exemplifies the significance of visual-spatial intelligence and well-structured instructional materials in preclinical training (Rohlin & Petersson, 2005).

2.2. Limitations of Live Demonstration

The live demonstration has been considered an effective teaching strategy for a long time due to its ability to provide immediate observation of technique and the opportunity for inquiries. However, its efficacy is constrained by various factors, such as unreliable delivery between sessions, a single exposure, and a restricted line of sight (Abdul Rahman et al., 2021). In large classes, not all students are able to observe the operative field or appreciate the subtle movements of the instrument. The absence of recording capabilities also hinders learners from reexamining challenging steps or studying anatomical variations.

2.3. Video-Based Demonstrations

Video-based learning offers an attractive solution to these limitations. Studies in dental education have shown that video demonstrations improve procedural understanding, motivation, and satisfaction (Alqahtani et al., 2015; Naseri et al., 2016). All of these principles are consistent with constructivist learning theory, as video instruction enables the standardization of content, self-paced learning, and multiple repetitions. Moreover, videos facilitate equitable access to learning material across different student cohorts.

2.4 Cognitive Load Theory and Multimedia Learning

According to Mayer's (2009) Cognitive Theory of Multimedia Learning, human understanding improves when visual and auditory information are presented together in an organized way. However, excessive or poorly synchronized information can increase cognitive load and hinder learning. Video-based instruction mitigates this by allowing students to control playback, manage information flow, and revisit complex steps at their own pace. When applied to a visually demanding procedure like endodontic access preparation, this approach can promote more profound understanding.

2.5 Technological Advances in Endodontic Pedagogy

Schwaiger et al. (2022) found that modern teaching tools, including microscope-assisted demonstrations, virtual simulations, and 3D-printed dental models, are becoming more and more popular because they help students stay interested. Nonetheless, these tools often prioritize exterior manipulation rather than inside visualization. The sagittal cross-sectional technique is often utilized in anatomy education to elucidate internal relationships; yet, it remains little explored within the realm of operational dentistry education. By integrating sagittal sectioning with microscope magnification, educators can provide a transparent, three-dimensional experience that connects theory and practice.

2.6 Gap in Literature

Although the advantages of video-based learning are well-documented, limited research has investigated cross-sectional or sagittal-view perspectives in the instruction of preclinical endodontic operations. Most of the earlier studies (Alqahtani et al., 2015; Naseri et al., 2016; Dabbour et al., 2018) contrasted video and live demonstrations with conventional camera angles. No published data exist on sagittal-view microscope videos in endodontic pedagogy. Therefore, this study not only contributes evidence on its demonstrative effectiveness but also introduces a novel instructional paradigm for visualizing endodontic anatomy and techniques. Traditional methods of instruction, such as live lectures and demonstrations, have been identified as having learning limits (Maresca et al. 2014). Large numbers of students often participate in such approaches, and repeating and/or reinforcing the teaching presents an inherent challenge. There is also little interaction between the teacher and the students, resulting in a passive learning style. In healthcare education, the Faculty of Dentistry, Universiti Teknologi MARA (UiTM), focuses on digital innovation transformation, notably in contemporary dental education. Within the dentistry faculty, there has been a steady trend towards technology-enhanced teaching approaches, including virtual learning environments, videotaped demonstrations, and blended learning modules. The development of a sagittal-view demonstration aligns with UiTM's vision of integrating innovation and accessibility in professional training.

3.0 Methodology

3.1 Study Design

A randomized controlled experimental design was adopted to compare the learning effectiveness of a sagittal-view video-based demonstration (VD) with that of a traditional live demonstration (LD) in preclinical endodontic training. The independent variable was the demonstration type; dependent variables were students' conceptual understanding, visual-spatial comprehension, and practical performance. Ethical approval was obtained from the Universiti Teknologi MARA Research Ethics Committee (Ref. FRC/03/2022 (ERP/20/32)).

3.2 Participants

Sixty second-year Bachelor of Dental Surgery students participated voluntarily after informed consent. The criteria for inclusion were finishing the basic dental anatomy course and not having any previous clinical experience in endodontics. A computer-generated sequence randomly put participants into either the LD ($n = 30$) or VD ($n = 30$) groups. The sample size met Cohen's (1992) recommendation for moderate effect detection (power = 0.8, $\alpha = 0.05$). All students had finished the lecture on endodontic access cavity preparation; nevertheless, they had not encountered any practical or visual demonstration.

3.3 Instructional Interventions

3.3.1 Live Demonstration (LD)

The LD group observed an endodontist doing endodontic access cavity preparation on an extracted maxillary central incisor. The endodontist detailed each phase, including instrument selection, angulation, and depth regulation. Students were arranged around the phantom head unit and prompted to inquire as shown in Figure 1.



Figure 1. Live demonstration given by lecturer

3.3.2 Sagittal-View Video Demonstration (VD)

The VD group viewed a six-minute sagittal-view instructional video, recorded using a 4K Carl Zeiss OPMI PICO dental operating microscope. The tooth was sectioned longitudinally, revealing the pulp chamber and canal trajectory. The video showed both occlusal and cross-sectional angles at the same time, along with voice-over instructions. The innovation of this video lies in its capacity to display the internal progression of the bur relative to external contours, as shown in Figure 2. The simultaneous depiction of internal and external anatomy transforms the invisible into visible learning, enabling cognitive mapping of the procedure in three dimensions that was previously absent in preclinical training media.

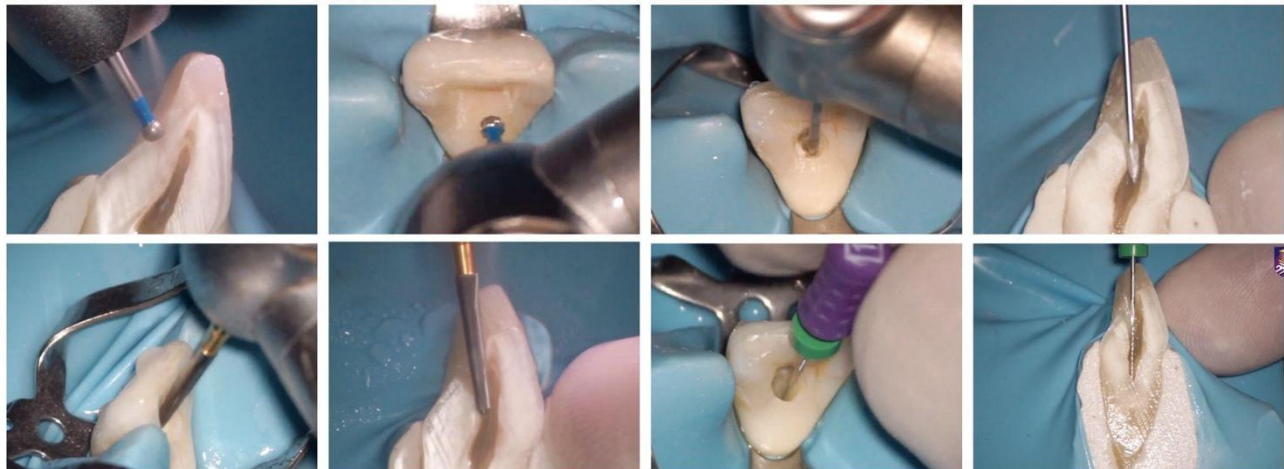


Figure 2. Sequential steps of endodontic access cavity preparation shown with corresponding sagittal-view visualization.

3.4 Assessment Tools

3.4.1 Cognitive Questionnaire

A validated 18-item questionnaire (Dabbour et al., 2018) assessed students' self-reported understanding across conceptualization, visualization, and implementation domains. Each item employed a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

3.4.2 Practical Performance Evaluation

Each student performed access cavity preparation on an extracted maxillary central incisor using a high-speed handpiece and endodontic burs. Five calibrated examiners, blinded to group allocation, evaluated outline form, roof removal, canal identification, and wall smoothness using a pass/fail rubric. Inter-examiner calibration produced a Cohen's $\kappa = 0.78$ ($p < 0.001$), confirming substantial agreement (Landis & Koch, 1977).

3.5 Data Analysis

Data were analyzed using IBM SPSS v27. Within- and between-group questionnaire differences were examined via repeated-measures ANOVA, while practical outcomes were compared using the Chi-square test. Significance was set at $p < 0.05$.

4.0 Findings

4.1 Questionnaire-Based Learning Outcomes

The analysis of pre- and post-demonstration questionnaires revealed significant within-group gains for both instructional methods. As shown in Table 1, the LD group demonstrated an improvement from a pre-test mean score of 3.21 ± 0.44 to a post-test mean score of 4.12 ± 0.38 , whereas the VD group improved from 3.18 ± 0.46 to 4.05 ± 0.41 . The impact of improvement was similar between the two groups, with mean increases of 0.91 and 0.87, respectively. Statistical analysis, however, showed no significant difference between the LD and VD groups ($p > 0.05$), indicating that both teaching methods were equally effective in enhancing students' cognitive understanding and self-perceived confidence.

Parameter	Live Demonstration (LD)	Video Demonstration (VD)	p-value
Pre-test mean $\pm$ SD	3.21 ± 0.44	3.18 ± 0.46	0.77
Post-test mean $\pm$ SD	4.12 ± 0.38	4.05 ± 0.41	0.63
Mean improvement (Δ)	0.91	0.87	0.68

Table 1. Summary of Learning Outcomes Between Live Demonstration (LD) and Sagittal-View Video Demonstration (VD)

As shown in Table 2, analysis of the item-level questionnaire results demonstrated that the strongest improvements occurred within the implementation domain (Q10–Q18). While the conceptualization (Q1–Q2) and visualization domains (Q3–Q9) showed only modest, non-significant increases ($p > 0.05$), the implementation items exhibited clear and consistent statistically significant

gains in both the live demonstration and video demonstration groups. Specifically, seven out of nine implementation domain including removal of the pulp-chamber roof, removal of calcified dentine, identification of canal orifices, creation of tapered axial walls, achievement of straight-line access, and attainment of the ideal outline form—showed significant pre- to post-intervention improvement ($p < 0.05$).

This pattern indicates that both teaching methods, particularly the sagittal-view video, were most effective in strengthening procedural understanding and hands-on confidence compared to theoretical comprehension or anatomical recognition. Because implementation domain require learners to mentally coordinate complex 3D internal structures, the sagittal-view video's ability to reveal the internal pulp chamber in real time likely contributed to the enhanced performance in this domain. Therefore, the findings in Table 2 confirm that the teaching innovation directly targets the area where students traditionally struggle most—transforming theoretical knowledge into accurate clinical execution

No.	Questionnaire	Live Demo Pre	Live Demo Post	p-value (LD)	Video Demo Pre	Video Demo Post	p-value (VD)
Conceptualization							
1	Understanding objectives of access preparation	2.83 ± 0.75	3.33 ± 1.47	0.09	2.70 ± 1.02	3.20 ± 1.58	0.10
2	Understanding procedural steps	3.07 ± 0.69	3.33 ± 1.54	0.08	2.63 ± 0.85	3.30 ± 1.44	0.06
Visualization							
3	Visualising pulp horns	2.97 ± 0.89	3.33 ± 1.35	0.07	2.90 ± 1.03	3.23 ± 1.36	0.09
4	Visualising calcified dentine	2.93 ± 0.98	3.33 ± 1.35	0.06	2.80 ± 1.06	3.20 ± 1.47	0.08
5	Identifying map on pulp-floor	3.00 ± 0.98	3.40 ± 1.35	0.06	2.73 ± 0.94	3.30 ± 1.44	0.05
6	Locating canal orifices	2.93 ± 0.87	3.23 ± 1.43	0.07	2.80 ± 1.03	3.30 ± 1.51	0.06
7	Visualising cervical dentine bulge	2.93 ± 0.98	3.17 ± 1.29	0.09	2.80 ± 1.06	3.23 ± 1.36	0.07
8	Visualising taper of axial walls	2.87 ± 1.04	3.27 ± 1.28	0.07	2.80 ± 1.10	3.30 ± 1.34	0.05
9	Visualising final outline form	2.93 ± 0.87	3.23 ± 1.52	0.10	2.83 ± 1.02	3.23 ± 1.48	0.07
Implementation							
10	Removing pulp-chamber roof completely	2.87 ± 0.94	3.30 ± 1.47	0.02*	2.70 ± 1.06	3.47 ± 1.43	0.01*
11	Removing calcified dentine	2.93 ± 0.98	3.27 ± 1.39	0.03*	2.80 ± 1.10	3.43 ± 1.38	0.02*
12	Following map on pulp floor	2.97 ± 0.96	3.37 ± 1.30	0.06	2.83 ± 1.15	3.27 ± 1.46	0.05
13	Preventing damage to pulp floor	3.03 ± 1.03	3.23 ± 1.36	0.09	2.80 ± 1.19	3.37 ± 1.35	0.05
14	Finding all canal orifices	2.97 ± 1.00	3.23 ± 1.45	0.03*	2.87 ± 1.22	3.50 ± 1.41	0.02*
15	Removing cervical dentine bulge	2.97 ± 1.00	3.17 ± 1.37	0.04*	2.73 ± 1.11	3.40 ± 1.40	0.03*
16	Creating tapered axial walls	2.93 ± 0.98	3.37 ± 1.27	0.03*	2.73 ± 1.01	3.37 ± 1.35	0.02*

17	Achieving straight-line access	2.93 ± 0.98	3.30 ± 1.39	0.02*	2.67 ± 1.09	3.43 ± 1.48	0.01*
18	Achieving ideal outline form	3.00 ± 0.91	3.23 ± 1.43	0.04*	2.77 ± 1.04	3.43 ± 1.41	0.03*

Table 2. Pre- and Post-Demonstration Self-Confidence Scores for All Questionnaire Items in Live and Video Demonstration Groups

4.2 Practical Performance Outcomes

Practical assessments conducted by calibrated examiners showed that students in the VD group achieved a higher overall pass rate (76.7%) compared with those in the LD group (63.3%), as shown in Table 3. Despite this numerical difference, statistical analysis demonstrated no significant difference between groups ($\chi^2 = 1.270$, $p = 0.260$). This indicates that, although the VD group performed better in observable terms, the improvement was not large enough to reach statistical significance within the sample size of the present study. These results align with the questionnaire findings, reinforcing the conclusion that the sagittal-view video demonstration performs at least equivalently to live demonstration in preparing students for hands-on endodontic tasks.

Group	Pass, n (%)	Fail, n (%)	X ² (Chi-square)	p-value
Video Demonstration (VD)	23 (54.8%)	7 (23.3%)	1.270	0.260
Live Demonstration (LD)	19 (63.3%)	11 (36.6%)		

Table 3. Comparison of Practical Performance Outcomes Between Video and Live Demonstration Groups

Discussion

The present study examined the comparative effectiveness of a novel sagittal-view video demonstration against the conventional live demonstration method for teaching endodontic access cavity preparation. Although both groups demonstrated comparable post-demonstration performance, the educational significance lies beyond the absence of statistical difference. The video method's ability to produce the same results as the traditional live demonstration confirms that it is both effective and pedagogically sound. The finding is particularly meaningful considering that video instruction allows flexibility, repeatability, and scalability that traditional demonstrations cannot provide. Seven questionnaire items exhibited significant within-group improvement. These included statements related to recognizing the purpose of the outline of the access cavity, understanding the direction and depth of penetration, identifying the roof of the pulp chamber, and achieving straight-line access. Each of these improvements corresponds to enhanced three-dimensional comprehension precisely in the domain targeted by the sagittal-view innovation.

The sagittal-view video's strength lies not in statistical superiority but in visual transparency. It grants students unprecedented insight into the internal morphology of the tooth, enabling them to visualize how the dental bur travels through enamel and dentine until the chamber roof is breached. In traditional teaching, this moment is described verbally, but in the sagittal view, it is seen. The internal anatomy, previously abstract, becomes spatial and clear. For novice learners, this clarity is transformative. Students often over-penetrate or misalign access preparations due to limited spatial imagination. Observing the chamber roof thinning in real time, under microscopic magnification, anchors mental models of depth and angulation. Such visual scaffolding minimizes procedural anxiety and fosters confidence traits critical to the progression from simulation to patient care. Clinically, understanding the internal-external correlation of access geometry reduces iatrogenic risks, such as perforation or missed canals. Educationally, it bridges the cognitive divide between static textbook images and dynamic operative reality.

This result aligns well with Mayer's (2009) Cognitive Theory of Multimedia Learning, which asserts that children learn most effectively when words and visuals are given concurrently in a cohesive manner. The sagittal-view video meets Mayer's concepts of spatial contiguity and temporal coherence by conveying narrative and images at the same time. By doing this, it reduces unnecessary cognitive burden and lets the learner's limited working memory focus on putting knowledge together in a way that makes sense. Likewise, Kolb's (1984) experiential learning cycle, which includes concrete experience, reflective observation, abstract conceptualization, and active experimentation, is thoroughly integrated into this pedagogical method. The video serves as a reflective observation that precedes hands-on practice. Because learners can replay the procedure, they repeatedly traverse Kolb's cycle, reinforcing motor planning and conceptual retention. Neuroscientifically, repeated exposure to motion-based imagery activates mirror neurons associated with imitation learning (Buccino et al., 2004). Watching fine-motor movements at close range

helps encode procedural sequences in motor memory even before direct execution, making first attempts smoother and more accurate.

The present findings align with multiple studies confirming that video-assisted instruction yields learning outcomes comparable to live demonstrations (Alqahtani et al., 2015; Naseri et al., 2016). Nevertheless, the novel sagittal-view perspective extends this literature by offering a visual field that reveals internal dynamics instead of merely the operator's external movements. Dabbour et al. (2018) observed that multi-angle video demonstrations enhance comprehension. The sagittal video operationalizes this principle at a micro-anatomical level. It does not merely change the camera position; it redefines the learning object itself—from an opaque tooth surface to a transparent system of planes and depths. This anatomical transparency introduces a paradigm shift analogous to how cross-sectional imaging transformed diagnostic radiology (Rohlin & Petersson, 2005).

The concept of sagittal transparency makes the ability to see the invisible, which embodies the educational novelty of this study. When the tooth is longitudinally sectioned, students gain a continuous reference line through the center of the pulp chamber. They see how the enamel cap transitions to dentine, how the bur's angulation must adjust, and when the chamber floor becomes visible. These visual signals eliminate the need for guesswork and promote what Schön (1987) referred to as "reflective practice." Students are no longer passive observers; they are engaged participants who analyze the rationale behind each action. The learning experience is elevated from procedural mimicry to conceptual mastery because of this transition from external observation to internal understanding.

In the context of UiTM's expanding dental cohort, maintaining consistency and quality in live teaching sessions poses logistical challenges. The sagittal-view video method provides a scalable and standardized alternative. Each cohort can access the same high-quality instruction, ensuring equitable learning opportunities. Furthermore, the resource integrates seamlessly with UiTM's Learning Management System and MOOC platform, aligning with national strategies for digital transformation in higher education. For faculty, it reduces redundancy and eliminates the need to repeat identical demonstrations, thereby allowing educators to devote more time to personalized feedback and formative assessment. This approach also has interdisciplinary value. The same technique could be adapted for other operative disciplines, such as tooth cavity preparation, crown preparation, or implant site drilling, broadening its impact across the curriculum.

Despite its encouraging outcomes, this research is not without limitations. The study measured short-term learning gains within a single academic setting. Longitudinal follow-up is required to evaluate knowledge retention and transfer to clinical competence. The binary pass/fail assessment limits sensitivity; future work should employ quantitative rubrics that measure accuracy in millimeters, wall divergence, and canal-orifice exposure. Furthermore, the existing design lacked qualitative feedback, and focus group interviews could yield more profound insights into students' perceptions of cognitive workload, confidence, and engagement.

Future studies might also integrate eye-tracking analysis to examine how learners visually navigate the sagittal screen. Combining sagittal video with augmented-reality overlays or transparent 3D-printed tooth models could further improve visual synchrony, thereby expanding the possibilities of simulation-based dental education.

5.0 Conclusion & Recommendations

This study affirms that the sagittal-view, microscope-assisted video demonstration represents a substantial pedagogical advance in preclinical endodontic training. By transforming a traditionally opaque procedure into a transparent, three-dimensional experience, it enables students to comprehend the spatial relationship between external landmarks and internal pulp-chamber morphology with a degree of clarity unattainable through conventional live demonstrations. The findings demonstrate that students exposed to this sagittal-view video achieved comparable conceptual understanding and practical competence to those who learned through traditional instruction, with the added benefit of enhanced visual depth and the capacity for self-paced review.

In addition to the equivalence of outcomes, the sagittal-view approach is innovative in its educational philosophy, which integrates cognitive theory, clinical precision, and digital accessibility. The method incorporates verbal explication, anatomical realism, and reflective repetition to support Mayer's multimedia learning principles and Kolb's experiential learning cycle. Consequently, it is in perfect harmony with the current trend of integrated, technology-enhanced education in Malaysian dental institutions and around the world.

Although this study was restricted to short-term learning within a single cohort, the findings emphasize the viability of incorporating sagittal-view media as a standard instructional adjunct. The long-term impact on clinical performance, its application to other disciplines, and its integration with emergent tools such as virtual or augmented reality should be the focus of future research. Consequently, the sagittal-view innovation does not merely enhance endodontic instruction; it also revolutionizes the process by which invisible anatomy is transformed into visible knowledge in dental education. Its adoption within UiTM's curriculum modernizes endodontic teaching and exemplifies the broader movement towards evidence-based, student-centered education in Malaysia and beyond.

Acknowledgement

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Paper Contribution to Related Field of Study

This study contributes to the field of dental education by validating an innovative sagittal-view video demonstration as an effective instructional approach for teaching endodontic access cavity preparation. By providing enhanced anatomical visualization and demonstrating learning outcomes comparable to conventional live demonstrations, this work broadens current pedagogical models and supports the integration of technology-enhanced instructional strategies within preclinical training.

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In Vitro Anticancer Activities of *Holothuria Leucospilota*: A Narrative Review

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Abstract

Holothuria leucospilota (HL) is an edible sea cucumber with promising in vitro anticancer activities. HL extract demonstrates high therapeutic selectivity against cancer cells while sparing normal cells. The extract disrupts cell cycle at both the early (G1) and late (S/G2/M) phases. The anticancer effects of HL are mediated by various mechanisms including the activation of the intrinsic apoptotic pathway via BAX upregulation and BCL-2 downregulation, suppression of tumor-promoting genes, inhibition of angiogenesis and preservation of cellular integrity through CDH1 upregulation. These findings highlight HL's multi targeted mechanisms and render it a potential marine-derived candidate for oncology drug development

Keywords: *Holothuria leucospilota*, anticancer, apoptosis, cell cycle arrest

1.0 Introduction

Cancer remains a major global health concern, accounting for approximately 9.7 million deaths in 2022 (Ferlay et al., 2024). The frequency of cancer differs between men and women, mostly attributed to diet and lifestyle, and gender-specific organs. The most common cancers affecting males, in descending order, are lung, prostate, colorectal, stomach, and liver cancers. In women, the organs mostly affected by cancers are the breast, colorectal, lung, cervical, and thyroid, in descending order (Thorn et al., 2011). The global burden of this disease continues to escalate each year, imposing significant physical, emotional, and financial burdens to individuals, families, communities, and the healthcare system. The International Agency for Research on Cancer (IARC) projects that the number of new cases would reach 32.6 million by 2045, highlighting the urgent need for effective and sustainable remedies (Ferlay et al., 2024).

Standard therapeutic modalities for cancer treatment encompass surgery, chemotherapy, and radiotherapy, which may be administered individually or in tandem (Mee et al., 2023). Despite numerous advancements in standard therapeutic approaches, they continue to be associated with several limitations that hinder the complete cure of cancers. Surgery, although fundamental to treatment, often results in significant mutilation and loss of organ functions. Chemotherapy frequently lacks the specificity required to exclusively target the malignant cells, leading to collateral damage to healthy tissues and a significant deterioration in patients' quality of life (Zafar et al., 2025). Moreover, drug resistance continues to pose a significant challenge in clinical settings, as cancer cells may exhibit reduced sensitivity to treatment. Further challenges encompass tumour heterogeneity, which promotes the survival of treatment-resistant subpopulations of cancer cells, resulting in disease recurrence and reduced survival rates (Mengistu et al., 2024). Addressing these issues requires the discovery of novel therapeutics that exhibit selectivity and relatively low toxicity. These agents must effectively surmount resistance mechanisms while enhancing clinical tolerability and patient quality of life.

The discovery and development of novel pharmaceutical candidates has increasingly shifted towards natural sources, with marine species proving to be rich reservoirs of bioactive metabolites. Marine organisms, especially those inhabiting high-pressure, competitive environments, generate unique, structurally diverse secondary metabolites for defence and communication (Li et al., 2023). These compounds, comprising triterpene glycoside(saponins), phenols, and sulfated polysaccharides, have demonstrated significant bioactivities, particularly anticancer, anti-inflammatory, and anticoagulant effects (Baharara et al., 2015; Kareh et al., 2018; Qian et al., 2015).

Among these marine resources, the tropical edible sea cucumber *Holothuria leucospilota* (HL), a species widely distributed across the Indo-Pacific region, has gained considerable attention. HL possesses a rich biochemical profile that exhibits

a wide range of biological activities, including anticancer, anti-inflammatory, and antioxidant properties (Althunibat et al., 2009; Baharara et al., 2016; Soltani et al., 2014, 2015). HL-derived fractions, particularly those rich in triterpene glycoside (holothurins) and protein extract, have been reported to inhibit cancer cell growth in concentration-dependent manners through selective cytotoxicity, apoptosis induction, metastasis suppression, and cell cycle arrest (Janakiram et al., 2015; Ru et al., 2022c; Wargasetia & Widodo, 2017). Given its potential as a promising anticancer candidate, this review aims to provide a comprehensive overview of the scientific evidence on the biological compounds and anticancer mechanisms of HL.

2.0 Literature Review

2.1 Morphology and Taxonomic Characteristics of *Holothuria leucospilota*

Sea cucumbers, members of the class Holothuroidea within the phylum Echinodermata, are a distinctive marine invertebrate inhabiting ecosystems that range from shallow coastal zones to deep-sea habitats. They represent one of the most species-rich groups of echinoderms (Purcell & Chantal Conand, 2016). The taxonomy of HL is presented in Table 1.

Table 1: *Holothuria leucospilota* taxonomy

Kingdom	Animalia
Phylum	<i>Echinodermata</i>
Class	<i>Holothuroidea</i>
Order	<i>Holothuriida</i>
Family	<i>Holothuriidae</i>
Genus	<i>Holothuria</i>
Species	<i>Holothuria Leucospilota</i>

(Adopted from Kamarudin & Rehan, 2015)

HL is a black, soft-bodied sea cucumber characterised by a smooth tegument and a consistent black hue (Figure 1). The morphology of HL, which can be classified into external and internal, is defined by an elongated body that tapers anteriorly, aligned along the oral-aboral axis, a ventral mouth at the anterior end encircled by 20 black, shield-like tentacles, and a subdorsal anus posteriorly. It features randomly dispersed podia and papillae, with its skin comprising spicules that include tables with enormous, multi-holed discs and spires, as well as both regular and irregular buttons. Although retaining the pentamerous symmetry characteristic of echinoderms, holothurians exhibit secondary dorsoventral differentiation, creating an apparent bilateral form (Eso et al., 2020). Fundamental echinoderm features, including a calcareous endoskeleton and water vascular system, are preserved, while particular species also possess specialised respiratory trees for gas exchange (Eso et al., 2020). Around the oral region is a ring of 10–30 modified tube feet that function as tentacles, typically arranged in multiples of five. The shapes, including peltate, dendritic, pinnate, digitate, or intermediate, are taxonomically consistent within a species (Eso et al., 2020). Holothurians differ from other echinoderms by their soft, armless body wall and, in some taxa, the presence of haemoglobin (Ceesay et al., 2019; Eso et al., 2020). Some species also develop Cuvierian tubules, unique defensive structures that can be ejected to deter predators (Ceesay et al., 2019). The morphology and anatomical structures of HL are illustrated in Figure 2.



Figure 1. The tropical sea cucumber *Holothuria Leucospilota* in its natural habitat

Posterior End

Anterior End

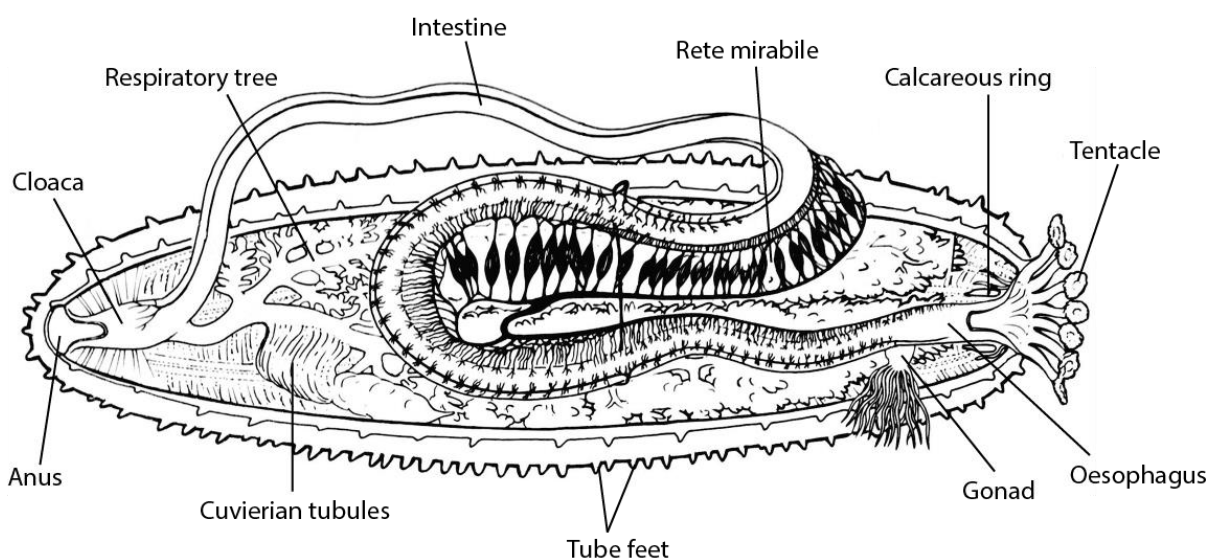


Figure 2. General anatomical structures of a sea cucumber.
[Adopted from Cannon & Silver (1986)]

In English, the terms “holothuroid” and “holothurian” are the standard scientific descriptors for sea cucumbers. In Malaysia, however, the terminology is diverse, reflecting the organism's cultural and economic associations. Common names for *Holothuria leucospilota* include *timun laut*, *bat*, *balat*, *brunok*, and *gamat*, while *hoi sum* is used within Malaysian Chinese communities (Kamarudin & Rehan, 2015). Malaysia's rich marine biodiversity supports many taxa; however, in Peninsular Malaysia, *gamat* usually refers to commercially valuable species of *Stichopus* (e.g., *S. herrmanni*, *S. chloronotus*, *S. horrens*, and *S. ocellatus*), which are traditionally harvested to produce gamat oil and water (Kamarudin & Rehan, 2015).

2.2 Bioactive compound of *Holothuria Leucospilota*

HL a common aspidochirotid sea cucumber distributed across the Indo-Pacific and Persian Gulf is widely recognised as a rich source of structurally diverse bioactives that hold potential for biomedical applications (Bordbar et al., 2011; Debi et al., 2025; Eso et al., 2020; Wibowo et al., 2019). Its biochemical profile comprises triterpene glycosides (saponins), phenolic compounds, flavonoids, sulfated polysaccharides, mucopolysaccharides, and small peptides (Baharara et al., 2016; Ceesay et al., 2019; Khaledi et al., 2022). These metabolites are primarily concentrated in the body wall, internal organs, and Cuvierian tubules.

Saponins from HL, commonly referred to as holothurins, are structurally characterised by a triterpenoid aglycone linked to sugar chains, often bearing sulfate groups (Wargasetia & Widodo, 2017). Their amphiphilic nature enables both membrane-disruptive and signaling-modulatory actions, contributing to cytotoxic, pro-apoptotic, and cell cycle-regulatory effects in various cancer cell lines (Han et al., 2009, 2010; Wang et al., 2014; Wargasetia & Widodo, 2017). The structural similarities of these holothurins to saponins found in medicinal herbs such as Ganoderma and Ginseng, combined with their chemical diversity, render them promising candidates for the development of anticancer drugs. (Bordbar et al., 2011).

Phenolic compounds, such as tannins and flavonoids, contribute significantly to the therapeutic characteristics of HL. Flavonoids, which constitute nearly half of all known plant phenolics, are abundant in sea cucumbers due to their seaweed-based diet. Marine-derived flavonoids such as catechins and flavonols differ structurally from their terrestrial counterparts, offering unique functional advantages (Ceesay et al., 2019). High concentrations of flavonoids have been reported in the gonads, muscles, and digestive tract of sea cucumbers. These compounds exhibit potent antioxidant and immunomodulatory properties, thereby enhancing host defense and potentially complementing direct anticancer mechanisms (Ceesay et al., 2019). Other metabolites, such as mucopolysaccharides and chondroitin in HL, enhance the nutraceutical value of HL by alleviating inflammation and joint pain, particularly in individuals with arthritis and connective tissue disorders, thereby supporting its ethnomedicinal relevance (Bordbar et al., 2011).

2.3 Extraction solvent of Holothuria Leucospilota

Common extraction solvents for *Holothuria leucospilota* comprise methanol, ethyl acetate, ethanol, n-hexane, and acetone. Methanol and water-methanol mixtures are often employed to extract a diverse array of bioactive compounds from various parts of the sea cucumber. Alternative solvents, such as ethyl acetate and n-hexane, are used for partitioning to isolate specific fractions.

The extraction yields and compound profiles vary significantly according to solvent polarity, extraction duration, and processing conditions (Ceesay et al., 2019). Polar solvents such as methanol and ethanol tend to extract higher yields of saponins, phenolics, and flavonoids, whereas aqueous methods favor polysaccharide recovery (Ceesay et al., 2019). This variability influences both the range of bioactive compounds produced and the results of subsequent bioassays. For instance, saponin-rich extracts may exhibit high cytotoxicity due to membrane disruption, whereas the polysaccharide-rich aqueous fraction from HL may show potent immunomodulatory or anti-inflammatory effects. Moreover, differences in the absolute concentration of the active compounds within crude extracts directly influence the calculated IC_{50} values. This emphasized the need for standardised extraction protocols in pharmacological research.

3.0 Methodology

3.1 Study design and search strategy

This paper presents a narrative review analysing and evaluating the existing literature on the anticancer activities of HL in vitro. The review focuses on studies reporting cell viability/cytotoxicity, apoptosis induction, cell cycle arrest, and gene expression. A literature search was conducted across major electronic databases (PubMed, Scopus, and Web of Science). A combination of keywords pertinent to HL, extracts, and the biological activity of interest. The primary search query was structured as follows: AB=("holothuria leucospilota" OR holothuria) AND AB=(anticancer OR antitumour OR antineoplastic). The search was limited to studies published in English up to the present date and accessible in full text.

3.2 Inclusion and exclusion criteria

The inclusion and exclusion criteria were established to ensure the selection of high-quality and relevant studies for this review. Original research articles focusing on in vitro studies that employed extracts or compounds isolated from HL were included. These studies must report data on anticancer activities, encompassing cell viability assay (MTT or MTS), apoptosis assay, cell cycle assay (flow cytometry), or gene expression analyses (qPCR). Conversely, research involving animals, meta-analyses, and conference abstracts or studies focusing on non-cancer activities were excluded.

3.3 Data extraction and synthesis

All retrieved abstracts were initially screened according to the established inclusion and exclusion criteria. Relevant articles were obtained in full text, and reviews were conducted for comprehensive data extraction. The extracted key data points included the utilised cell lines, the type of extract or component derived from HL, the reported IC_{50} values, and the mechanistic outcomes observed. The extracted data were analysed and categorised into cytotoxic activity, induction of apoptotic pathways, and modulation of tumor-promoting gene expression to enhance critical discussion and ensure consistency of reported evidence.

4.0 Findings

4.1 Anticancer Activities

Previous studies have demonstrated the anticancer activities of HL against a broad range of human cancer cell lines. The anticancer mechanisms primarily involve disruption of the cell cycle, induction of programmed cell death (apoptosis) and modulation of key signaling pathways associated with carcinogenesis, angiogenesis, and metastatic cascades.

4.2 Antiproliferative and cytotoxicity effect

Cytotoxic effect reflects the effectiveness of a compound in inhibiting the growth of cancer cells that is assessed based on the half maximal inhibitory concentration (IC_{50}) values, which represent the concentration of the compound required to inhibit 50% of cell viability. Lower IC_{50} values indicate greater cytotoxic potency, reflecting the compound's effectiveness in suppressing cancer cell proliferation. It has been shown that the cytotoxic potency of HL extracts differs based on the extraction solvent and the type of cancer cells. Table 2 provide a comprehensive summary of all reported IC_{50} values, clearly illustrating the low concentrations required to achieve 50% cell death in various carcinoma cells.

In colorectal (Caco-2) and cervical (HeLa) cancer cells, hexane extracts produced IC_{50} values of 107.6 $\mu\text{g/ml}$ and 189.1 $\mu\text{g/ml}$, respectively. Ethyl acetate extracts exhibited comparable potency, with IC_{50} values of 112.4 $\mu\text{g/mL}$ (Caco-2) and 120.2 $\mu\text{g/mL}$ (HeLa). In contrast, methanol fractions were less potent, exceeding 250 $\mu\text{g/ml}$ in Caco-2 and 221.5 $\mu\text{g/ml}$ in HeLa cells (Mashjoor & Yousefzadi, 2019). Comparable patterns were noted in MCF-7 breast cancer cells, with the hexane extract producing an IC_{50} of 189 $\mu\text{g/ml}$, in contrast to 120.2 $\mu\text{g/ml}$ for ethyl acetate and 221.5 $\mu\text{g/ml}$ for methanol, thereby highlighting the enhanced efficacy of less polar extracts (Mashjoor & Yousefzadi, 2019). Notably, refined solvent fractions exhibited significant potency in HeLa cells, with IC_{50} values of 0.301, 0.210, 2.29, and 0.229 $\mu\text{g/ml}$, following 72 hours of treatment with hexane, dichloromethane, butanol, and aqueous extracts, respectively, demonstrating that particular solvent fractions of HL possess considerable cytotoxicity against cervical cancer cells. (Vaseghi et al., 2018).

In another study, cervical carcinoma (C33A) and lung adenocarcinoma (A549) cells exhibited IC_{50} values of 10 $\mu\text{g/ml}$ and 28 $\mu\text{g/ml}$, respectively, following 48 hours of incubation with HL extract (Althunibat et al., 2009). Similarly in a recent study, it was demonstrated that after 48 hours of incubation with the extract, the growth of colon carcinoma (HCT-116), prostate cancer (PC3), and hepatocellular carcinoma (HepG2) cells was reduced, yielding IC_{50} values of 32.4 $\mu\text{g/ml}$, 40.1 $\mu\text{g/ml}$, and 18.1 $\mu\text{g/ml}$, respectively (Kandeil & Atlam, 2023). However, the extract exhibited moderate antiproliferative activity against breast cancer (SKBR3) cells with an IC_{50} value of 50 $\mu\text{g/mL}$ observed after 48 hours of treatment (Khaledi et al., 2022).

Several studies reported that saponin-rich extracts exhibited significant cytotoxicity. In MCF-7 breast cancer cells, saponins demonstrated strong anti-proliferative potency with an IC_{50} of 6 $\mu\text{g/ml}$ (Soltani et al., 2015). Similarly, in A549 lung cancer cells, saponins displayed potent cytotoxicity at 1 $\mu\text{g/m}$ (Soltani et al., 2014). The anticancer effects of HL are reported to be dose- and time-dependent, showing enhanced cytotoxic and antiproliferative activities with increased concentrations and prolonged exposure durations. For instance, gastric cancer (MKN45) cells exhibited time-dependent sensitivity following treatment with HL, with IC_{50} values of 400 $\mu\text{g/ml}$ at 24 hours and 75 $\mu\text{g/ml}$ at 48 hours (Sadegh et al., 2025).

4.3 Cell cycle arrest

The cell cycle comprises a series of regulated sequential events that control cellular growth, DNA replication, and subsequent cell division. The process is typically divided into four phases; G_1 , S, G_2 , and M, each governed by various molecular checkpoints and regulatory proteins that orchestrate cell cycle progression. Specifically, the progression is halted at G_1/S and G_2/M checkpoints to allow for DNA repair and avert the replication of damaged genetic materials. Irreparable damage induces cellular apoptosis. Cancer cells evade cell cycle arrest due to mutations in regulatory genes, notably the loss of function in tumour suppressor genes such as p53. These mutations disrupt checkpoints designed to halt cell division for DNA repair, allowing cancer cells to proliferate uncontrollably and activate pathways that promote growth and circumvent apoptosis.

It has been shown that HL possesses the capability to disrupt cell cycle progression at multiple checkpoints depending on the cancer type. Protein extracts from HL have been reported to selectively affect cancer cells while sparing normal fibroblasts (NIH-3T3), keratinocytes (HaCaT), and bronchial epithelial cells (16HBE) (Ru et al., 2022). In HepG2 cells, treatment with HL protein extract induced G_0/G_1 arrest, halting progression into DNA synthesis. A similar trend was observed in A549 cells, whereby an increased G_0/G_1 population was recorded after treatment, consistent with restriction-point arrest and growth suppression. In contrast, Panc02 cells with IC_{50} of 17.175 $\mu\text{g/ml}$ displayed a different profile, with reduced G_0/G_1 population and a marked accumulation in the S and G_2/M phases, suggesting that the extract interfered with DNA synthesis and mitotic entry (Ru et al., 2022).

Furthermore, saponin-rich fractions resulted in cell cycle arrest at S-phase in MKN45 cells, reflecting impaired DNA replication and checkpoint activation, alongside time-dependent proliferation inhibition with IC_{50} values of 400 $\mu\text{g/ml}$ and 75 $\mu\text{g/ml}$ at 24 and 48 hours respectively (Sadegh et al., 2019). Similarly, in breast cancer cells (MCF-7), saponins induced a significant increase in the sub- G_1 peak, suggestive of apoptotic DNA fragmentation, while simultaneously reducing proliferative cell fractions

(Soltani et al., 2015). These findings confirm that HL-derived compounds can exert effects at both early (G1) and late (S/G2/M) phases of the cell cycle.

4.4 Induction of apoptosis

Apoptosis is a programmed cell death mediated by caspase enzymes, serving as a fundamental mechanism to eliminate damaged, aged, or infected cells. In cancer, the malignant cells often evade apoptosis through multiple mechanisms, including the overexpression of anti-apoptotic proteins, downregulation of pro-apoptotic proteins, and dysregulation of death receptor signaling pathways.

Ru et al. (2022) provide compelling evidence regarding the apoptotic selectivity of HL for cancer cells. They demonstrated that HL protein extracts induced significant cell death with an average apoptotic rate of 40% across three distinct cancer cell lines (HepG2, A549, and Panc02). Conversely, the protein derived showed negligible toxicity towards normal fibroblast (NIH-3T3), keratinocytes (HaCaT), and bronchial epithelial cells (16HBE). This therapeutic index observed is notably distinct from that of conventional chemotherapeutic agents such as Epirubicin (EPI), which lack comparable selectivity and consequently induce apoptosis and necrosis in both cancer and normal cells (Ru et al., 2022c).

The pro-apoptotic activity of HL is not restricted to the protein that was derived from the sea cucumber. Khaledi et al. (2022) demonstrated that the methanolic extract of HL, anticipated to encompass a wider array of saponins and polar compounds, can induce significant apoptosis, reaching 45% at a concentration of 50 µg/ml in SK-BR-3 breast carcinoma cells (Khaledi et al., 2022). This suggests that the capabilities to induce cell death is a broad spectrum feature of HL bioactives, regardless of the cancer cells origin or the polarity of the extract. These studies collectively affirm that HL extracts are effective and selective anticancer agents.

4.5 Analysis of gene expression

Molecular studies on HL have provided important insights into the regulatory mechanisms of gene expression underlying its anticancer activities. As detailed in Table 3, gene expression analyses revealed that HL-derived fractions regulate the balance between pro-apoptotic and pro-survival genes, as well as genes involved in angiogenesis, growth factor signaling, and cell adhesion.

In breast cancer cells (MCF-7), saponin-rich extracts demonstrated a clear effect on apoptosis-related gene expression. Treatment with 6 µg/ml induced a strong upregulation of the BAX gene, a pro-apoptotic member of the Bcl-2 family, while concurrently reducing the expression of BCL-2, a major anti-apoptotic gene. This shift in the BAX/BCL-2 ratio favors mitochondrial permeabilization and cytochrome c release, activating intrinsic apoptotic pathways (Bokhari & Hamar, 2023; Lee et al., 2025). These gene expression patterns are consistent with the observed morphological features of apoptosis, such as nuclear condensation and cytoplasmic blebbing (Ru et al., 2022). Furthermore, saponin fraction from HL modulates genes associated with angiogenesis and tumor-promoting signaling. Specifically, gene expression analysis revealed the downregulation of VEGF-D and TGF-β following treatment (Baharara et al., 2015). VEGF-D plays a dual role, promoting both angiogenesis and lymphangiogenesis through its binding to VEGFR2 and VEGFR3, and emerges as one of the key players in cancer evasion and metastasis, while TGF-β contributes to immune evasion and tumor progression (Soltani et al., 2014). In addition, acidic mucopolysaccharide fraction of HL exerts anti metastatic effects by directly inhibiting angiogenic sprouting and tumor cell invasion (Zhang et al., 2009). Their suppression indicates that HL extracts not only induce cell death but also inhibit pathways essential for tumor growth and metastatic dissemination.

In gastric carcinoma cells (MKN45), gene expression analysis indicated an inverse trend, with upregulation of FN1 (fibronectin 1) and CDH1 (E-cadherin) following saponin treatment (Sadegh et al., 2025). FN1 is linked to extracellular matrix interactions, whereas CDH1 is a key cell–cell adhesion molecule, and its loss typically promotes epithelial–mesenchymal transition (EMT) and metastasis. The restoration or upregulation of CDH1 therefore implies that HL compounds could play a role in preserving epithelial integrity and inhibiting metastatic activities, adding another dimension of anticancer potential beyond mere growth inhibition and apoptosis

Table 2: Summary of *Holothuria leucospilota* cytotoxicity studies

References	Extract Type	Cell Lines	IC ₅₀ (µg/ml)
(Mashjoor et al., 2019)	Hexane	Caco-2	107.62
		Hela	189.09
	Ethyl Acetate	Caco-2	112.44
		Hela	120.2
	Methanol	Caco-2	>250
(Mashjoor et al., 2019)	Hexane	Hela	221.5
			189
	Ethyl Acetate	Mcf-7	120.2
			221.5
(Ru et al., 2022a)	Protein	HepG2	17.175
		A549	10.658
		Panc02	17.481
		NIH-3T3	8.493
		HaCaT	9.282
		16HBE	3.489
(Soltani et al., 2014)	Saponin fraction	MCF-7	6
(Althunibat et al., 2009)	Organic solvent	C33A	10
		A549	28
(Khaledi et al., 2022)	Methanol	SKBR3	50
(Kandeil & atlam, 2023)	Ethanol	HCT-116	32.44
		PC3	40.13
		HepG2	18

Table 3: Summary of *Holothuria leucospilota* anticancer activities

Biological studies	Extract Type	Cell Lines	Findings	References
Cell cycle assay	Protein	HepG2	Cell cycle arrest at G2/M	(Ru et al., 2022a)
		A549		
		Panc02		
		NIH-3T3		
		HaCaT		
	Saponin	16HBE	Cell cycle arrest at S and G2/M	
Apoptosis assay	Protein	MKN45	Cell cycle arrest at S phase	(Sadegh et al., 2025)
		HepG2	Apoptotic population after treatment 40%	(Ru et al., 2022b)
		A549		
		Panc02	Apoptotic population after treatment 5%	
		NIH-3T3		
		HaCaT	Apoptotic population after treatment 15%	
	Methanol	16HBE	Apoptotic population after treatment 11%	
		SK-BR-3	Apoptotic population after treatment 45%	(Khaledi et al., 2022)
Gene expression (qPCR)	Saponin fraction	MCF-7	Upregulation BAX expression and downregulation of BCL-2 expression	(Soltani et al., 2015a)
		MKN45	Upregulation of FN1 and CDH1 in MKN45 cell lines.	(Sadegh et al., 2025)
		MCF-7	Downregulation of VEGF-D, and TGF-B	(Soltani et al., 2015b)

4.0 Conclusion & Recommendations

Holothuria leucospilota exhibits significant anticancer properties by inducing cytotoxic effects and cell cycle arrest, promoting apoptosis, and modulating cancer-associated gene expression. The extracts and fractions demonstrate a selective affinity for cancer cells, effectively preserving normal cells, thereby highlighting its therapeutic specificity. Through the modulation of critical pathways including BAX/BCL-2, VEGF-D, and CDH1, HL demonstrates multi-targeted mechanisms to inhibit tumour growth and progression. This paper concludes the anticancer potential of HL in-vitro; however, in-vivo and clinical studies are warranted to validate its efficacy and safety.

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Paper Contribution to Related Field of Study

This paper contributes to the growing field of marine pharmacology and cancer therapeutics by consolidating mechanistic evidence on the anticancer properties of HL. It advances the understanding of solvent-dependent extraction variability, selective cytotoxicity effects and different phases of cell cycle disruption and arrest in cancer cells exerted by HL extract. Additionally, the mechanisms of anticancer effects governed by specific regulatory genes were discussed. These insights support the development of marine-derived compounds as selective, low toxicity alternatives to conventional chemotherapeutic approach and provide a foundation for future translation research in oncology drug discovery.

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Immunoinformatics Prediction of Conserved Dengue Virus Epitopes for Community Health Preparedness

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Abstract

Dengue outbreaks in Malaysia continue to harm community health. Dengue virus T-cell epitopes were identified using MHC2Pred bioinformatic tools. Polyprotein sequences from global prototype and Malaysian strains were analyzed, revealing twenty conserved epitopes across all serotypes. Most epitopes were located in non-structural proteins NS5 and NS4B, with strong binding to HLA Class II alleles. The epitope sequences were also found to be non-homologous to the human sequence, suggesting no reaction to the human autoimmune response. These findings highlight the role of immunoinformatics in supporting vaccine development and improving community preparedness against dengue.

Keyword: Dengue, immunoinformatics, MHC Class II, vaccine

1.0 Introduction

Dengue fever remains one of the most significant vector-borne diseases in tropical and subtropical regions, including Malaysia. Recurring outbreaks contribute to rising morbidity, mortality, and public-health burdens, particularly in densely populated urban areas. Environmental changes, climate variability, and human behavioural patterns further influence the spread of the *Aedes* mosquito vector (Sarker et al., 2024). Despite ongoing control efforts, an effective universal vaccine remains unavailable, mainly due to the genetic diversity of the dengue virus (DENV) and the complex host immune response.

The challenge of developing a safe and broadly protective dengue vaccine lies in identifying conserved epitopes that can stimulate effective immune responses across all DENV serotypes (Caradonna et al., 2022). Traditional experimental approaches are time-consuming and costly, highlighting the need for computational strategies to accelerate vaccine discovery. Recent advances in immunoinformatics and reverse vaccinology have demonstrated their effectiveness in identifying conserved epitope targets across multiple flaviviruses (Verma et al., 2021; Chen et al., 2024). In addition, the approach for using computers, also known as reverse vaccinology, has been widely used in COVID-19, Yellow fever, and the Zika virus. In Covid-19 vaccine development, bioinformatics approaches were employed to design and develop a novel multi-epitope vaccine against 2019-nCoV that can potentially trigger both CD4⁺ and CD8⁺ T-cell immune responses, and to investigate its biological activities using computational tools (Enayatkhani et al., 2021; Ong et al., 2020). Similarly, in yellow fever, a multi-epitope vaccine was designed to elicit an immune response, utilizing advanced immunoinformatic and molecular modeling techniques by predicting B- and T-cell epitopes using the sequences from all structural (E, prM, and C) and nonstructural proteins of 196 YFV strains (da Silva et al., 2024; Dhanushkumar et al., 2024). For the Zika virus, an effort has been initiated to develop a vaccine using a computational approach (Buitrago-Pabón et al., 2024; Zhe-Yu Peng et al., 2024).

This study addresses this gap by applying the Major Histocompatibility Complex Class II Prediction (MHC2Pred) tool to identify potential T-cell epitopes within dengue virus polyproteins. By comparing global prototype and Malaysian DENV strains, the research aims to pinpoint conserved epitopes with high binding affinity to human leukocyte antigen (HLA) class II alleles, providing valuable insights for future epitope-based vaccine design and national dengue-control preparedness programme.

2.0 Methodology

This study employed a bioinformatics-based approach to identify conserved T-cell epitopes within dengue virus (DENV) polyproteins that could contribute to vaccine development and enhanced public health preparedness.

1.1 Data Sources and Computational Tools

Protein sequences of DENV polyproteins were retrieved from the GenBank database at (<https://www.ncbi.nlm.nih.gov/genbank/about/>). Several online bioinformatics platforms and servers were used in this study, including MHC2Pred for T-cell epitope prediction (<http://crdd.osdd.net/raghava/mhc2pred/>), WebLogo 3.0 for visualising sequence conservation (<https://weblogo.threeplusone.com/>), BLASTp for sequence homology comparison (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>), and the Epitope Conservancy Analysis Tool from the IEDB database to assess sequence conservation (<https://tools.iedb.org/conservancy/>). The UniProt database was used to obtain and convert protein sequences to FASTA format, while ClustalW (via MEGA X) facilitated multiple-sequence alignment across DENV serotypes.

1.2 Selection of Viral Sequences

DENV polyprotein sequences representing global prototype strains and Malaysian isolates were selected to identify conserved epitopes with potential cross-serotype reactivity. This comparative approach aimed to highlight epitopes suitable for vaccine design relevant to both regional and international contexts. DENV Polyprotein from prototype and Malaysia strains that are used in this study are shown in Table 1.0 and Table 2.0, respectively.

Table 1.0: Information on the dengue virus serotype from the global prototype strain

DENV-1 Strain: Mochizuki Accession number: AB074760.1 FASTA format link: https://www.ncbi.nlm.nih.gov/protein/BAD16759.1?report=fasta
DENV-2 Strain: New Guinea Cosmopolitan Accession number: M29095.1 FASTA format link: https://www.ncbi.nlm.nih.gov/nucore/M29095.1?report=fasta
DENV-3 Strain: H87 Accession number: M93130.1 FASTA format link: https://www.ncbi.nlm.nih.gov/nucore/M93130.1?report=fasta
DENV-4 Strain: H241 Accession number: AY947539.1 FASTA format link: https://www.ncbi.nlm.nih.gov/nucore/AY947539.1?report=fasta

Source (Sanchez-Burgos et al., 2010).

Table 2.0: Information on dengue virus serotype from the strain in Malaysia

DENV-1 Strain: P72-1244 Accession number: ABR13878.1 FASTA format link: https://www.ncbi.nlm.nih.gov/protein/ABR13878.1?report=fasta
DENV-2 Strain: DKD811 Accession number: ACN94866.1 FASTA format link: https://www.ncbi.nlm.nih.gov/protein/ACN94866.1?report=fasta
DENV-3 Strain: CNR 17046/2012 Accession number: AVY51409.1 FASTA format link: https://www.ncbi.nlm.nih.gov/protein/AVY51409.1?report=fasta
DENV-4 Strain: CNR 16861 Accession number: QBA29684.1 FASTA format link: https://www.ncbi.nlm.nih.gov/protein/QBA29684.1?report=fasta

Source (Touret et al., 2019).

1.3 Epitope Prediction and Analysis

Both structural and non-structural DENV protein sequences were submitted to the MHC2Pred server at (<http://crdd.osdd.net/raghava/mhc2pred/>) to predict T-cell epitopes binding to human leukocyte antigen (HLA) class II alleles. Default parameters were applied for allele selection and threshold scoring. A threshold score greater than 1.5 can be selected in order to discriminate the binders from nonbinders. The epitopes possessing a score greater than the cut-off score are predicted as binders, or

else they are predicted as nonbinders (Lata et al., 2007). In this study, epitopes with threshold scores greater than 1.5 were shortlisted for further analysis..

1.4 Evaluation of Epitope Conservation

The shortlisted epitopes were analysed using the IEDB Epitope Conservancy Analysis Tool (<http://tools.iedb.org/conservancy/>) to determine conservation across all DENV serotypes. Peptides with $\geq 80\%$ binding probability were considered favorable, and those demonstrating 100% conservation were prioritized for deeper investigation. Sequence alignment using ClustalW (application in MegaX software (<https://www.megasoftware.net/>)) confirmed the similarity among DENV serotypes from global and Malaysian datasets.

1.5 Visualisation and Validation

Conserved epitopes were visualised using WebLogo 3.0, which graphically represents amino-acid conservation at each sequence position. To minimise potential autoimmune risks, predicted epitopes were screened using BLASTp against human and murine protein sequences. Any epitope exhibiting substantial similarity to host proteins was excluded. The remaining non-homologous epitopes were considered strong candidates for future vaccine development.

3.0 Results and Discussion

3.1 Epitope Prediction and Conservation

Using the MHC2Pred server, eight dengue virus (DENV) polyprotein sequences from four global prototype strains and four Malaysian isolates were analysed to identify potential T-cell epitopes from all DENV serotypes (DENV1-4). From these eight DENV genome samples, both the global prototype and Malaysian strains yield 80 epitopes each, for a total of 160 analyzed in this study. Out of these 160 epitopes, only 20 epitopes with the highest peptide score (above 1.5) and high conservation percentage (above 80%) were selected and summarised in Table 3.0 below.

Table 3.0 Summary of Potential T-cell Epitope Found from both Structural and Non-Structural DENV Protein obtained using MHC2Pred tool.

Protein Source	No.of Conserved Epitopes	Representative Alleles	Peptide Score Range	Example Peptide Sequence	Conservation (%)
NS5	8/20	DQ7, DR3, DR15, DR4	1.9 – 2.4	TFDTEYPKT, IYDSKFEKQ	80 – 100
NS4B	3/20	DQ8, DRB1*0101, DR13	1.9 – 2.3	AIKDNRAVH, SKVRSNAAI	90 – 100
NS3	3/20	DR3, DR9, DQ7	1.8 – 1.9	ELIGRARIS, LQRKHGGS	85 – 100
NS1	4/20	DQ7, DQ8	1.9 – 2.4	PPTAGVLAR, MHTALTGAT	80 – 100
NS4A NS2B					
Envelope Capsid	2/20	DRB1*1501, DR3	1.9 – 2.0	KVVKVLRPT, TDTPFGQQ	85 – 95

There are three main characteristics of predicted epitopes of the dengue virus obtained in this study. Firstly, the epitope sequences produce a high peptide score (above 1.5) and are considered as strong binders to human leukocyte antigen class II alleles (Lata et al., 2007). The high peptide score is considered to have high potential to trigger a T cell-mediated human immune response and could be a good choice in designing epitope-based vaccines for further study and predicted as immensely immunogenic and highly antigenic (Sanchez-Burgos et al., 2010; Khan et al., 2017).

Secondly, the epitope sequence is most conserved because they are most likely to induce an immune response against all serotypes (Sanchez-Burgos et al., 2010). A high conservation percentage indicates a broader level of protection across multiple strains of DENV serotypes than epitopes derived from variable DENV genome regions (Bui et al., 2007; Caradonna et al., 2022).

Thirdly, there is no similarity between the epitope sequence and the human sequence to avoid the autoimmune response in the human body (Ahmed et al., 2020). All twenty epitopes from both strains (prototype and Malaysia) are not similar to the human sequence. The result is displayed in Figure 1.0 below.

Description	Scientific Name	Max score	Total Score	Query cover	E value	Per. Ident	Length	Accession No.
polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3391	QHR82515.1

Figure 1.0

[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QHR82521.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QTX93474.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QTX93446.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QHD57352.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QFS19474.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QTX93374.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QTX93593.1
[dengue virus 3] polyprotein	Dengue virus 3	32.5	32.5	100%	5.9	100.00%	3390	QPI11916.1

BLASTp result shows very low maximum score and high E value, which indicates there is no similarity between the DENV epitope sequence with the human or murine sequence.

When a DENV epitope sequence lacks similarity to a human sequence, it prevents autoimmune responses driven by molecular mimicry. Molecular mimicry is a condition in which epitope components that resemble human proteins will induce autoantibodies or T cell reactions that can react with the human body's own tissue and hence, will subsequently lead to severe disease manifestations like haemorrhage and vascular leakage in DENV haemorrhagic fever and dengue shock syndromes (Syuan Yang et al, 2025; Maoz-Segal & Andrade, 2015).

3.2 Comparative Conservation and Immunogenicity

According to Table 3.0, most conserved epitopes were found in non-structural proteins (NS5, NS4B, and NS3), with a smaller proportion in structural proteins such as the envelope and capsid. The distribution of dengue virus from global prototype strains, as compared to the Malaysian strain, is given by the following: for non-structured gene 5 (NS5) as 8/20, non-structured gene 4b (NS4b) and non-structured gene 3 (NS3) respectively as 3/20, non-structured gene 1 (NS1) at 2/20, and 1 of each non-structured gene 4a (NS4a), non-structured gene 2b (NS2b), and capsid and envelope polyprotein. To sum up, epitope immunogenicity is observed in 90% of non-structural proteins (NS5, NS4b, NS3, NS1, NS4a, and NS2b) compared to 10% in structural proteins (capsid and envelope proteins). These observations align with previous reports by Verma et al. (2019), which demonstrated that NS5 and NS4B are the dominant epitope-bearing regions of DENV.

The predominance of conserved epitopes within non-structural proteins reflects their functional importance and evolutionary stability. Similar findings have been reported in recent computational studies highlighting NS5 and NS4B as critical immunogenic regions across flaviviruses (Mustafa et al., 2022; Rahman et al., 2025). Non-structural proteins, especially NS5, play essential roles in viral replication and immune modulation, making them promising targets for universal T-cell-based dengue vaccines. The identification of such epitopes across both global prototype and Malaysian DENV strains reinforces the potential for cross-serotype and regionally adaptable vaccine designs, consistent with the immunoinformatics-based approaches described by Zulkifli et al. (2023) in Malaysian isolates.

This work emphasises the investigation of non-structural dengue virus components for vaccine development; nevertheless, the significance of structural proteins such as envelope, capsid, and pre-membrane also warrants similar investigation. Focusing on structural polyproteins, such as the Envelope protein domain III (EDIII), offers promising avenues for the development of next-generation vaccines. Non-structural proteins, including NS1, NS3, and NS5, play crucial roles in pathogenesis and immune evasion, making them important targets for therapeutic intervention and vaccine development (Ali et al., 2025). A thorough comprehension of both structural and non-structural components is crucial for the invention of viable vaccines and coordinated public health measures to address the global burden of dengue.

3.3 Public-Health Relevance

From a public-health perspective, integrating computational immunology with surveillance of Malaysian dengue strains enhances preparedness for future outbreaks. Predicting conserved epitopes can inform vaccine formulations tailored to regional virus populations, ultimately supporting national dengue control and prevention strategies.

4.0 Conclusion

This study demonstrates the efficacy of immunoinformatics in identifying conserved T-cell epitopes within dengue virus (DENV) polyproteins, thereby enhancing future vaccine development. Through comparative analysis of both international and Malaysian DENV strains, twenty highly conserved epitopes were identified, predominantly within non-structural proteins such as NS5 and NS4B. These epitopes exhibited strong binding affinities to multiple HLA class II alleles, suggesting their potential to elicit broad and robust immune responses across diverse populations.

The consistent conservation pattern across strains underscores the biological stability and immunological significance of these non-structural regions. The absence of sequence similarity to human proteins further supports their safety as vaccine targets. Collectively, these results validate the use of computational prediction tools like MHC2Pred as an efficient and reliable approach for early-stage vaccine research. However, since this study predominantly employs an *in silico* approach, the results should be validated using conventional laboratory methods without compromising the authenticity or originality of the work. The integration of immunoinformatics platforms with wet lab validation is anticipated to improve predictive accuracy and expedite the validation of vaccine candidates.

From a public health perspective, this research contributes to Malaysia's preparedness to combat dengue outbreaks by providing a scientific basis for regionally relevant epitope-based vaccine design. The findings also highlight the need for continued collaboration between computational biology and clinical immunology to translate predictive models into practical solutions for dengue prevention.

5.0 Summary

Overall, this study confirms that bioinformatics-driven epitope prediction offers an efficient and cost-effective approach for identifying potential vaccine targets. The strong conservation of NS5- and NS4B-derived epitopes across DENV serotypes highlights their immunological relevance and practical application in developing broadly protective dengue vaccines. These findings not only contribute to scientific understanding of DENV immunogenicity but also hold direct implications for community health resilience and preventive vaccine research in endemic regions such as Malaysia.

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7.0 Paper Contribution to Related Field of Study

This paper will contribute significantly to the *in silico* study of immunogenicity of dengue virus by investigating the potential of MHC Class II prediction tools to identify the most conserved epitope in the dengue polyprotein. It will subsequently lead to a safer, more robust, and cost-effective approach to vaccine development for dengue virus.

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